Reinterpreting Mobile Learning: an Activity Theoretic Analysis of the Use of Portable Devices in Higher Education

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Declaration

I declare that this thesis is a presentation of my original research work and has not previously been submitted for a degree from any university. To the best of my knowledge, this thesis does not contain any material previously published or written by another person except where duly acknowledged in the text.

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Abstract

Although there is growing interest in investigating mobile learning, it is not well conceptualised. This thesis investigates the concept of 'mobile learning' by exploring students' routine learning activities mediated by the use of tools and taking place in multiple contexts. The exploration does not focus on what and whether students are learning; rather, it focuses on how they use tools to accomplish learning practices. This involves exploring the relationship between context and learning practices.

This thesis draws on three case studies that examined the use of portable devices in two Institutions of Higher Education with different contexts: traditional learning and portable-technology assisted learning. The methodology used in the studies focused on collecting data that reflects on students' actual utilisation of portable devices and the continuity of that in different contexts (formal and informal) using observations and log files collected from students' portables. In addition, it considered triangulating students' self reports collected through questionnaires and interviews. Moreover, the methodology aimed at capturing the context of learning activities to consider and understand the relationship between context and learning activities. The empirical data was analysed using the concepts of activity theory (Engeström, 1987) and a theory of mobile learning (Sharples et al., 2007c).

The research led to presenting a conceptualisation of mobile learning using activity theory based on the concept of context-crossing. Context is embodied as the physical as well as the social features of the learning activities which also influences and is influenced by learning activities. The study also found that both new and old portable devices are important for students engaged in mobile learning, however, new portable technologies enable students to practise learning activities and create contexts that students using conventional devices could not do or create.

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Chapter 1

Introduction

This thesis focuses on investigating the concept '*mobile learning*' and developing a theoretical foundation of the term that does not suffer from the limitations of the current definitions. In order to conceptualise mobile learning, this thesis examines students' established use of portable devices to accomplish their routine learning practices in formal and informal settings. It does not aim to study how the utilisation of these devices impacts students' learning outcomes; rather, it examines the concept of *tool mediation* to understand students' utilisation of portables to accomplish their routine educational *practices*. Focusing on students' learning practices, instead of whether and what students are learning, is an approach derived from the understanding that learning is an integral aspect of activity in and with the world at all times (Lave, 1993). The conception of learning in this thesis is also supported by the view that learning is related to how people appropriate tools in a given culture or society (Saljo, 1999). Practices are defined in this thesis as routine patterns of activities repeated over time in a social context. Activities are any form of doing that is mediated by the use of tools (physical and conceptual), directed towards achieving an objective. The definition of practice is left open here to include any process that aids learning. For example, note taking during a lecture is considered in this thesis as a learning practice because through this practice a student puts together resources that are related to the topic discussed during the lecture which might help shape their understanding or be used later for revision purposes.

In this thesis, a portable device is defined as any device (old and new) that can be carried around and used to aid students' learning such as handouts, books, mobile phones, Personal Digital Assistants (PDA), tablet PCs, and laptops. Although some researchers might not consider laptops as portable technologies due to their size and weight, they are classified in this thesis as portables. This is because, as will be shown in the studies conducted in this thesis, they can be used in the same manner as PDAs and are in pervasive use by the learners studied. Moreover, laptops were used to engage in learning activities in multiple physical locations regardless of their size and weight. This issue is further discussed in Chapter 5. The terms *technologies, devices, artefacts* and *tools* are used interchangeably throughout this thesis to refer to the portable devices used by students to mediate their learning activities in formal and informal settings. A formal setting in this thesis is considered as the location

where students' learning is directed by an instructor; other settings where instructors are not present are considered informal. The definition of informal settings is further discussed in Section 2.2.3.

The concept of *tool mediation,* discussed in Chapter 3, plays an important role in studying students' learning activities in this thesis as it helps with understanding how students use portable devices to accomplish their routine study practices in different contexts and how these tools affect learning activities. Tool mediation is defined here as how tools (portable devices) are used to accomplish certain objectives. Tools are usually used to mediate the relationship between the subject (a student) and the object (goal) that a student wishes to achieve within a specific context. Context is conceptualised here as the physical and social setting of learning activities. The different conceptions of context are presented in Section 3.3 and the one most suitable for studying mobile learning and therefore used in this thesis is discussed in Section 3.4.3. Moreover, studying students' learning activities, and developing a conceptualisation of mobile learning, requires understanding the relationship between context and learning activities as these take place in different locations at different times. In this thesis, context is considered as a factor that influences and is influenced by learning activities. This is discussed in Chapter 3.

The remainder of this chapter discusses the motivation of the study, provides a brief background of the research field, lists the research questions, overviews the studies that were undertaken, states the contributions and significance of the research and provides an overview of the chapters to follow.

1.1 Motivation

This thesis emerged from the researcher's experience of lecturing in a university for a few years. The researcher noticed during this period that the number of students owning portable technologies (e.g. mobile phones, PDAs, and laptops) was continuously increasing mainly due to the quick advancement of the capabilities of these devices and the drop in their prices, making them affordable to a larger number of students. Students increasingly carried their devices to the university and used them to assist their learning practices although they were not required by the institution. This drew the researcher's attention to the potential of portable technologies to aid learning and the possibility of using these devices to provide advantages and learning opportunities that are not provided by other types of conventional devices. In addition, in this sense, the researcher perceived mobile learning as a significant approach to learning as it has the potential of promoting learning in different contexts and encouraging

learning in informal as well as formal settings. For instance, students had the ability to engage in learning, problem solving, and getting access to resources, search and communication capabilities whenever and wherever suitable. For these reasons and others, the utilisation of portable devices to aid students' learning became one of the goals of many universities. Therefore, it is crucial to understand what mobile learning is, what devices students use to aid their learning, how these are used in different formal and informal settings and what the relationship between context and learning activities is.

1.2 Research Background

Portable technologies such as personal digital assistants (PDAs), mobile phones, laptops and tablet computers have become increasingly integrated into the daily activities of humans including educational ones. The number of mobile phone owners has risen in the last few years (e.g. 75% of the general population in the UK, 90% of young adults; Crabtree et al. (2003)) and the capabilities of these devices are increasing at a steady rate.

Portable technologies are used in education to support students' learning inside and outside the classroom (Demb et al., 2004), lifelong learning (Sharples, 2000), and location-based experiences (Price et al., 2003; Weal et al., 2003). Higher education (HE) institutions are increasingly utilising these technologies by providing students and academics with portable technologies to be used for learning and teaching (Zelin and Baird, 2002; Demb et al., 2004; McVay et al., 2005). This is because these devices are believed to offer education a number of benefits such as: portability, accessibility and convenience (Kukulska-Hulme et al., 2005). Moreover, educational institutions are motivated to use portable technologies for teaching and learning because they, as reported by Savill-Smith and Kent (2003) on the use of palmtop computers, are relatively inexpensive and offer the possibility of ubiquitous computing. The devices also offer access to information and promote the development of information literacy, collaborative learning, and independent learning.

The introduction of portable technologies in education motivated many researchers to explore the opportunities and limitations introduced by these technologies for teaching and learning in different settings. It also triggered many efforts to develop theories and conceptualisations of a fairly new, complex and multidiscipline phenomenon: mobile learning. However, despite the existing number of interesting studies, the overarching problem remains that these have not led to a well conceptualised understanding of mobile learning. Different researchers defined the term differently (discussed in Section 2.3.1). Some focused on the mobility of the devices (e.g. Kukulska-Hulme et al., 2005), others considered mobile learning as an extension

to electronic learning (e-learning) (e.g. , 2000), and others focused on the mobility of the learner (e.g. O'Malley et al., 2003) and the context where learning activities take place (e.g. Sharples et al., 2007c). In addition, researchers usually associate mobile learning with handheld devices that are lightweight and small such as mobile phones and PDAs. This thesis aims to develop a theoretical foundation of mobile learning through empirical studies focusing on the continuity of learning activities that take place in different contexts (formal and informal) as a unique feature of mobile learning. The exploration of the term is not limited to handheld devices, but explores the devices that students use as part of their routine learning activities such as laptops and conventional devices like handouts and books. Meanwhile, mobile learning is defined as learning that is supported by portable devices (old and new) and takes place in different spaces at different times. The exploration of mobile learning in this thesis draws on current conceptions informing the field by researchers such as Sharples et al. (2007c). This thesis also aims to explore and position these written proposals more clearly, to understand mobile learning and the variety of dimensions of the term. It, then, can be considered as a contribution to the conceptualisation of the field, developing proposals offered by existing researchers.

The introduction of portable technologies in education also raised many questions about students' utilisation of these devices to accomplish their learning practices. Much research, which is reviewed in the next chapter, focused on investigating the utilisation and adaptation of new portable devices in HE students' learning practices, collaboration with others and social lives. However, few publications to date have studied the established use of these devices by HE students when used as part of students' routine study practices that take place in different contexts. Therefore, the key research questions that guide this research are as follows:

1. What is mobile learning?
2. How do students in Higher Education utilise portable technologies in formal and informal settings?
3. What is the relationship between context and students' learning activities?

1.3 Overview of studies

Three studies were conducted in this thesis to investigate the research questions. Each study examined the use of portable devices in different contexts:

1. The pilot study looked at the utilisation of handouts, mobile phones and laptops in two traditional higher education courses. This study is described in Chapter 5.

2. The second study investigated the utilisation of old and new portable devices in three courses in a university that implements a campus wide laptop program. A detailed description of this study is provided in Chapter 6.
3. The third study examined the utilisation of old and new portable devices in both formal and informal settings. It took place in the same university where the second study was conducted. The study also investigated students' utilisation of portable devices in hospital placement. This study is discussed in Chapter 7.

The methodology used to conduct these studies included both qualitative (questionnaires, observations, log files, interviews) and quantitative (questionnaires) data collection methods. The methodology focused on collecting data that reflects on and provides detailed description of students' actual use of technology in different contexts using observations and log files generated by system monitoring software installed on students' portable technologies. The methodology also focused on triangulating students' self reports, collected through questionnaires and interviews, regarding their perceptions and technology utilisation with the data collected through observations and log files. Moreover, the methodology considered collecting information about the context of learning activities as context is considered in this thesis as a factor that influences and is influenced by learning activities. The studies relied more on qualitative data sources for the majority of the findings. The methodology is discussed in detail in Chapter 4.

The data collected from the studies was analysed using activity theory (Engeström, 1987) to examine the process of tool mediation and describe how students use portable devices as part of their routine study practices. Activity theory was also used to develop a conceptualisation of mobile learning. In addition, a theory of mobile learning developed by Sharples et al. (2007c) was used to analyse the data and develop an understanding of the concept of mobile learning and to identify the dimensions that define the term. The analytical frameworks and their relationship to the research are discussed in Chapter 3.

1.4 Contributions of the Thesis

This thesis contributes to the field of educational technology, especially the current discussion of mobile learning, by providing a conceptualisation of mobile learning that addresses the limitations of the current definitions. This thesis shows that mobile learning can be studied by examining learners' activities that are directed towards achieving the same objective in and across multiple contexts (physical and social). It also presents a novel use of activity theory as an analytical framework for exploring mobile learning.

In addition, this thesis contributes to the literature exploring students' utilisation of portable devices (old and new) to accomplish routine learning activities in different contexts which is limited in the literature. The literature mainly focuses on studying students' adaptation of new technologies. This thesis shows that students use both old and new portable devices to aid their routine learning practices that take place in different contexts. The studies also showed that using portable technologies enables students to accomplish tasks and create contexts that students using conventional devices could not do or create. In addition, this thesis examines the influence of portable technologies on students' learning practices by investigating the benefits and limitations of using portable technologies to facilitate learning activities. This issue has not been widely discussed in the literature. The studies showed that using portables to aid learning has both positive and negative influences on students' learning activities. The influences are mainly related to the properties of the devices used which enrich and restrict activities.

Moreover, this thesis investigates the relationship between context and learning activities considering context as the combination of the physical as well as social features of learning activities. The research also studies the impact of the change in context on learning activities through investigating students' learning practices in different formal and informal settings considering both old and new devices. This contrasts with the studies in the literature, which mainly focus on studying students' learning activities in specific subject areas using portable technologies to accomplish specific purpose tasks. In addition, this thesis investigates some of the issues that have been relatively neglected in the literature such as studying the impact of instructors' technology utilisation on students' technology utilisation and investigating the impact of context on students' communication in formal and informal settings.

Furthermore, this thesis offers methodological ideas and considerations for research in mobile learning in terms of the methods used to collect data, the challenges and concerns raised by the choice of these methods, sample studied, and time required to study students' learning activities in formal and informal settings. This thesis' main methodological contribution is in attempting to overcome the limitations of the methodologies proposed in the literature by, first, collecting data on students' actual use of portable devices in different contexts. Second, triangulating students' self reports with data gathered through other techniques, and third considering the relationship between context and learning activities.

Parts of the work presented in this thesis have been previously published in refereed publications; a list of the publications is included in Appendix H.

1.5 Significance of the study

This thesis is of significance to the domain of educational technology as it explores a contemporary and debatable research topic of 'mobile learning'. Increasingly, researchers attempt to develop conceptualisations of the term using different perspectives. In addition, as the research area is expanding, this thesis is considered a step within the current and ongoing evolution of this area of research which aims to clarify misconceptions and help other researchers reach better informed interpretations of work in this area. This thesis introduces a conceptualisation of mobile learning based on empirical studies and one that does not suffer from the limitations of the current definitions. It also uniquely uses activity theory to develop the conceptualisation of mobile learning. The definition introduced here can help educational technology researchers in investigating mobile learning especially those interested in developing theories of mobile learning.

In addition, this thesis is relevant to researchers examining students' utilisation of portable devices (old and new) to accomplish learning activities in different contexts (formal and informal). It particularly focuses on a worthwhile and limited issue of exploring students' utilisation of portables as part of their routine learning practices. This thesis also adds to the current discussion on the relationship between context and learning activities and the conceptualisation of context that is most useful for studying mobile learning. It shows the importance of considering the social context as well as the physical context when defining mobile learning. Furthermore, the research provides a number of methodological considerations helpful for researchers studying mobile learning. These help with overcoming the limitations of the methodologies in the literature, which suffer from over-emphasising students' self reports. These considerations highlight the importance of collecting detailed data that represents students' learning activities in different formal and informal settings, triangulating self reports and collecting data about the context of learning activities.

Moreover, this thesis is relevant to educational policy makers as it provides information about students' utilisation of devices in different contexts and the implementation of campus-wide laptop programs. The findings of the research are also useful for guiding research on the design of learning resources for students on the move. Furthermore, the findings are beneficial for educators interested in utilising technology as a tool to aid teaching and learning where it highlights the importance of aligning the implementation of technology with changes in curriculum and delivery methods. These issues are further discussed in Chapter 8.

1.6 Overview of Thesis

The remainder of this thesis describes the theoretical and technical background of this research, the research methodology and presents the findings of the studies conducted.

Chapter 2 sets the background of this research by providing a review of the literature that examines the educational uses of information and communication technologies (ICT) in general and portable technologies in particular focusing on the various uses of these technologies in higher education institutions. The chapter also provides a review on mobile learning and its current conceptions.

Chapter 3 discusses the theoretical background to this research, focusing on the main concepts of activity theory that have informed this thesis and a mobile learning theory developed by Sharples et al. (2007c). The chapter also discusses the central themes of context and tool mediation.

Chapter 4 describes the methodology used to conduct the studies including instrument selection, sample selection, data collection and data analysis. The chapter also addresses how each of the research questions is answered through the selected methods and how data is analysed using the analysis tools.

Chapter 5 discusses the pilot study that was conducted to examine the methodology and its ability to investigate the research questions. The chapter also aims to understand 'mobile learning' and 'context'. The chapter presents the study's setting, data collection, data analysis, study findings and some potential answers to the research questions. The chapter also proposes some modifications for more efficient data collection and analysis for the subsequent studies.

Chapter 6 discusses the second study that implements some of the modifications proposed in the pilot study chapter. Again, this chapter discusses the study setting, data collection, data analysis, findings and more answers to the research questions. The chapter validates some of the modifications and highlights some issues that need to be further investigated in subsequent studies. The chapter also presents a new conceptualisation of mobile learning which was developed based on the empirical studies.

Chapter 7 discusses the main study conducted to investigate the research questions of this thesis. The mobile learning model developed in the previous chapter is used in this chapter to analyse the research data and validate the model.

Chapter 8 concludes this thesis by summarising its purpose, reviewing the findings of the three studies and discussing what the findings reveal about the conceptualisation of mobile learning and the utilisation of portable technologies to accomplish routine study practices in formal and informal settings. The chapter also lists this thesis' main contributions and limitations, discusses any possible directions for further research and outlines its implications on educational policy and practice.

1.7 Summary

This chapter provided an overview of the research presented in this thesis. In the next chapter, the literature is investigated to provide an overview of the research area to identify specific gaps in the literature that require further study and investigation.

Chapter 2

Literature Review on the use of Portable Technologies in Higher Education

This chapter sets the scene for discussion through the rest of this thesis by reviewing the literature on the educational uses of information and communication technologies (ICT) in general and portable technologies in particular. The chapter begins by reviewing the introduction of ICT in education and goes on to explore how technologies can effectively be 'integrated' in education to make their use beneficial for both students and instructors. This is followed by a brief discussion of the barriers that obstruct the integrating of technologies in education and how these can be overcome. After that, the chapter discusses the educational uses of different portable technologies (e.g. Personal Digital Assistants 'PDAs' and laptop computers) in formal and informal settings. The chapter then focuses on discussing current efforts to conceptualise mobile learning. The aim of this discussion is to provide an overview on the complexity and fragmentation of this field of research.

2.1 An overview of ICT in Higher Education

Information and communication technologies (ICT) are defined as 'a diverse set of technological tools and resources used to communicate and to create, disseminate, store and manage information' (Blurton, 1999). The use of ICT in education primarily began in the 1980s when attempts were made to embed ICT in educational practices especially in classrooms (Bigum and Green, 1993). In the early days of research into ICT in education, the focus was largely limited to how computers can most effectively be introduced into the classroom. Schools and universities used computers, which were considered as computational devices, mainly to automate existing processes (Fox, 1999). The substantial technical achievements at that time included the introduction of multimedia personal computers into schools and colleges, their connection to the Internet and the development of some useful educational software (Sharples, 2003).

The introduction of ICT in education, especially higher education, is motivated by some internal and external forces that affect higher education teaching (Fulp and Fulp, 2002; de

Boer et al., 2003) and research processes (de Boer et al., 2003). In terms of the internal motivations, some are initiated by instructors' personal interests in improving teaching and learning (Maier et al., 1998; de Boer et al., 2003) and others are initiated by institutions' changing policies and missions (Fox, 1999). Institutional policies and technology availability are two interrelated factors that affect the utilization of technology in higher education because the changes in institutions' missions and policies affects the type of technology provided to students and instructors and visa versa.

External factors that motivate the introduction of ICT in education are wide-ranging and caused by governmental and policy developments, demographic changes, market forces, the growth of knowledge economy, and internationalisation (Maier et al., 1998; de Boer et al., 2003). Institutions introduce ICT to align themselves with these changes.

In addition, technological developments, such as the availability of digital media and access to digital tools, applications and networks, affect the utilisation of ICT in higher education in both formal and informal settings (Blurton, 1999; Beyth-Marom et al., 2003). ICT in education is realised by a variety of new devices and technologies including desktops, notebooks, and handheld computers; digital cameras; local area networking; the Internet; CD-ROMs and DVDs; and applications such as word processors, spreadsheets, simulations, electronic mails (emails), videoconferencing and virtual reality which provide higher education with a wide variety of experiences that support teaching and learning.

The educational uses of computers are often separated in terms of student use and teacher use (Scaplen, 1999). In terms of students' use, computers have been used in education in a variety of ways. Taylor (1980) suggests that a computer can be used by students as a: *Tutor*, *Tool* and *Tutee*. The computer may be used to aid learning a module of content (*Tutor*) in terms of drill and practice, tutorials, simulations, demonstrations, and problem solving. It can also be used by students to assist them as they complete a task (*Tool*), for example through using word processors, databases, spreadsheets, graphics programs, telecommunications, and other special application software. Finally, computers can be used to help students to build and test ideas (Tutee), which generally involves programming and theory.

In terms of teachers' use, computers are used as teaching tools such as electronic white boards, which facilitate presentations and demonstrations. They are also used by teachers at the administrative level as management and organisational tools to develop courses, lesson notes, worksheets and tests and to post information on-line for students (Scaplen, 1999). The use of computers by teachers is not limited to the institutional introduction and

implementation of technology in teachers' practices. Some creative educators get involved in pilot projects that facilitate computers for teaching. For example, interested primary teachers got involved in a digital video-editing project which aimed at investigating 'how creativity could be integrated within existing structures and courses of initial teacher education' (Potter, 2006, p. 51). In this project, the trainees were introduced to the basics of filming and digital video cameras and editing with computers and were required to use these to film short clips. They were also asked to use a number of resources to complete the production such as music, narrative text, and titles using visual effects.

Fox (1999) argues that using technology is potentially valuable for higher education as it helps learners to partake in the knowledge society. In addition, she argues that the successful introduction of technology in higher education requires support from the institutions' leadership and adequate technology infrastructure to disseminate the use of technology in the university as a whole.

> The way the university thinks, feels and acts toward technology must be restructured, and the way to achieve this objective is to weave the IT organization throughout the university infrastructure... This restructuring of the IT organization requires a metatonia - a shift of mind - because, while a change in infrastructure can facilitate the potential of the information age, only the people in the organization can transform potential into reality. It requires a shift in the minds of university leadership, of the IT leadership and staff, and of the IT customers which include faculty, staff, and students. This metatonia will require them to look at the organization in a new and different way as interdependent groups, departments and individuals rather than isolated areas of structure. (Fox, 1999, p. 4)

Thus, the effective use of ICT in education implies 'integrating' it in educational practices. The following section briefly discusses what the integration of technologies in education means, how ICT can be integrated in higher education and the barriers that obstruct technology integration along with some proposed solutions to overcome these problems.

2.1.1 Integrating ICT in Education

Since technologies penetrated people's lives, technologies such as telephones, mobile phones and computers (e.g. automatic cash machines) have became 'integrated' into society. These devices are no longer supplementary tools, added to what existed before; they are used naturally and 'invisibly' (Cornu, 1995). The same should apply to education: students and teachers should use technologies in education invisibly and automatically in order to accomplish their routine tasks. Cornu (1995) defines 'integration' as 'combining parts in a whole' and the 'incorporation of new elements in a system'. Thus, the integration of technology in education is not about adding computers to classrooms or curricula nor treating

technologies as another subject in the curriculum, but it is about considering technologies as embedded tools in pedagogy, assessment, professional development, administration, university structure, incentives and partnerships for learning among schools, businesses, homes and community settings (Cornu, 1995; Dede, 1998; Walsh, 2002). This makes integrating technologies in education a crucial concern and a difficult process.

Many researchers, like Cornu (1995), Seels (1995) and Gardner (2004), have agreed that to integrate technologies in education, the use of these technologies should be transparent. For example, Seels (1995) argues that technologies must be incorporated in education so that the infusion of instructional technologies across the curriculum becomes transparent and their use in teaching becomes automatic. Similarly, Gardner (2004) stated that technology should be transparent in that resources must be designed and configured for pedagogic needs, not for the sake of the technology. Furthermore, Cornu (1995) suggests that technology will be natural, easy and have an effect on teaching and learning only when students and teachers use them to accomplish routine practices without preparation or thinking about it. This means that students and teachers must believe that in order to complete a task, they need to use a particular technology.

Integrating technology in education is impeded by a number of factors. Some of these are caused by external factors, such as access to technology, funding and cost, and administrative and technical support (Ginsburg and Elmore, 2000). Other barriers are internal - related to teachers and students - such as ownership (Edyburn and Gardner, 1999), personal fear of technology, reluctance to adapt technology, lack of training or expertise, and lack of resources and time to integrate technology in teaching and learning (Giordano and Trufant, 2002).

In terms of teachers, Bucklow and Clark (2003) argue that the integration of ICT in many areas of learning and teaching has transformed students' learning environments in ways that demand new forms of teaching and learning support. Thus, the effective integration of ICT in education requires educators to have ICT skills, the ability to control ICT use in the classroom and curriculum and the ability to cope with technical failure (Lao, 2000; Sime and Priestley, 2005; Szuba et al., 2005). Educators should also have ready access to technology (hardware and software) and time to practice so that they can develop their skills, confidence and approaches to teaching. Moreover, educators need support from administrators, staff and IT coordinators to integrate technology in teaching and learning effectively (Lawson and Comber, 1999). Furthermore, educators require continuous education that focuses on the pedagogical use of technology and how to incorporate it in the curriculum (Wilson, 2003). This also requires a sophisticated understanding of curriculum development and change

processes (Oliver and Dempster, 2003) and revising educational policies and practices, which will allow technology to have an impact on the educational system (Norton and Sprague, 1997). Although the proposed supports above can help effectively integrate technology into education, they can be difficult to implement because changing teachers' behaviour and/or an institution's operational practices, requires a lot of effort, and may not produce positive results.

In terms of students, the effective integration of technologies in education requires dealing with students' resistance to technology. Researchers like Bonwell and Eison (1991), Taylor (1986) and Alexiou-Ray et al. (2003) showed that some students feel confusion, anxiety, tension and loss of confidence when they try something new. These feelings are also a result of the conflict between students' past educational experiences and the new practices which require a shift in their conception of what learning involves (e.g. shift to self-directed learning) and what constitutes appropriate roles of students and teachers (Taylor, 1986; Akerlind and Trevitt, 1999). These feelings arise especially when changes have been imposed externally (e.g. by the instructor) and the person feels relatively little control over the event (Woods, 1996). Students would also fear learning less, as the time spent acquiring new learning skills takes away from the time spent on content (Bonwell and Eison, 1991).

Therefore, the successful integration of technology in education requires managing students' resistance and stress. This can be done by helping students to feel confident in their ability to handle the new circumstances by introducing educational technologies gradually along with the development of students' appropriate skill. This requires communicating to students, as clearly as possible, what is required of them and introducing activities to increase their confidence in their ability to meet the requirements (Akerlind and Trevitt, 1999). Students' technology resistance can also be overcome by describing the new approaches to teaching and learning that instructors chose and explaining the reasons for them; providing students with opportunities to reflect on the advantages and disadvantages of the traditional and innovative approaches; and presenting evidence, if available, from previous student evaluations of similar courses, plus any studies in the area (Akerlind and Trevitt, 1999). Lastly, students' resistance to technology may be caused by students' conception of computer-based teaching, which is often associated with a reduction in teacher-student contact and interaction, where students are expected to take personal responsibility for the development of their knowledge and management of their learning. In these cases, students' resistance can be overcome by encouraging and clarifying that there is an appropriate conception of learning to any kind of teaching, and especially computer-based teaching (Laurillard, 1993). Laurillard recommends creating an environment where students can develop their conception of learning and allowing

teachers to demonstrate their own commitment to the subject, and their way of approaching it. In addition, she recommends giving students opportunities to exercise choice in their method of study and defend their choice, and providing them with opportunities for discussing the knowledge in the subject, how it can be known and how it may be learned.

2.1.2 A note on learning

This section discusses the definition of learning that is used in this thesis. This helps with setting the boundaries of the exploration of the literature and thus the rest of this thesis.

The definition of learning in this thesis draws on Saljo's (1999) view of learning which is based on sociocultural theories of learning and human activity. He argues that

> Human learning has always been a matter of mastering tools of different kinds, intellectual (such as, for instance, becoming competent in how to do a division or a multiplication by using algorithms) as well as physical (learning how to build a house or how to cultivate land). A fundamental assumption in a sociocultural understanding of human learning is precisely this: learning is always learning to do something with cultural tools (be they intellectual and/or theoretical). This has the important implication that when understanding learning we have to consider that the unit that we are studying is people in action using tools of some kind .... The learning is not only inside the person, but in his or her ability to use a particular set of tools in productive ways and for particular purposes. (Saljo, 1999, p. 147)

Saljo also analyses Wertsch's (1991) view that learning is related to how people appropriate tools for thinking and acting that exist in a given culture or society.

The definition of learning in this thesis also draws on constructivist theories where learners are conceived to construct knowledge rather than just receive and store it. Brown and Campione (1996) argue that recently learning theories view learners as 'active constructors rather than passive recipients of knowledge'. In addition, Sharples (2000, p. 180) argues that:

> Personal learning starts with a learner in a social, cultural and technological environment. The act of learning involves the artful deployment of the environment, including its tools and resources, to solve problems and acquire new knowledge. Learning is a constructive process of acting within an environment and reflecting upon it. Action includes solving problems, engaging in dialogues of enquiry, and acquiring new knowledge. Reflection involves the learner in abstracting from a situated activity, to integrate the current experience with previous knowledge and to construct new interpretations.

Drawing on the above discussion, learning in this thesis is perceived as a process of utilising tools to accomplish activities in different contexts (formal and informal). Thus, the focus of this thesis, is to explore learners' utilisation of tools (physical and conceptual) to support their learning activities, which is also an important part of research in educational technology. The

exploration of learners' activities in this thesis is not concerned directly with the *consequences* of these activities, which might be described as learning outcomes.

2.2 Portable Computers in Higher Education

As discussed above, since the 1980s desktop computers were used to support teaching and learning for in-class and computer lab activities in higher education. Universities used to position desktop computers in classrooms or in computer laboratories for students and staff to support learning and teaching. However, these universities found that placing computers in specific rooms affected the use of the technology because students could not use them flexibly when needed or use them on demand outside the classroom or the university (Kontos, 2001; Schaumburg, 2001). To overcome the limitations of computers in classrooms and laboratories, educators started to provide students with educational experiences whenever and wherever they are, through portable devices such as Personal Digital Assistants (PDA) and laptop computers (Soloway et al., 2001; Lundin and Magnusson, 2003; Roschelle, 2003; Sharples, 2003). The introduction of portable devices in education was also motivated by the continuous technological developments of these devices, their portability, and their wide use among students which suggests they could be utilised to benefit learning (Corlett et al., 2005). This motivated a shift in the use of computers in education from occasional, supplemental use to frequent, integral use (Soloway et al., 2001; Tinker and Krajcik, 2001). Lehner and Nösekabel (2002) clarify however that mobile/electronic education should not replace traditional education but support both students and teachers by providing them with services that facilitate teaching, learning and education-related administrative tasks.

Portable computers, such as PDAs, mobile phones, laptops and tablet PCs, are self-contained computers that can be carried around and used either with a battery pack or mains power supply (Greasby and Greene, 1997). They have computing, communication and information storage and retrieval capabilities. Different types of portable computers have different features and capabilities, which affect the context in which they are used. One type of portable device is the handheld computer. These are portable devices that are small enough to be held in the user's hand, such as PDAs. They have many useful features such as their small size and light weight which make handling them in the palm of the hand or carrying them in a pocket easy. In addition, they can be used instantly, with little or no boot up time (Lockitt, 2005) and can be used in remote locations for a considerable length of time. PDAs have many features including access to calculator, clock, calendar and address book; facilities to view files such as spreadsheets, word documents and pictures; play video and audio files and computer games; access the Internet through wifi capability; and sending and receiving emails and files. However, PDAs have small screen size that makes viewing the displayed content difficult. In

addition, entering data is a problem. Some PDAs use a stylus and touch screen to input data through a handwriting recognition system. Others use small keyboards that can be attached to the PDA (Lockitt, 2005). In some PDAs data can be entered through a built-in keyboard. The text entry limitations may never fully be overcome because of the size constrains of handheld computers (Waycott, 2004).

Although handheld devices have some limitations, their features create new opportunities for their adaptation in and outside the classroom. For example, the size of handheld devices makes them easier to carry and therefore their use becomes more convenient. They fit easily in contexts such as location-based experiences. They have also been used successfully to encourage students' collaboration and interaction in the classroom (Fulp and Fulp, 2002) since students can move carrying their PDAs with them to solve problems and engage in group exercises. In addition, PDAs have wireless communication capabilities that can be used to connect to local area networks, access the Internet and emails, and talk to other people (Roschelle and Pea, 2002). Handhelds are also used to support time and information management, record and store notes and for reading e-books (Waycott, 2002).

Laptop computers are another type of portable computer used in education. They are small portable computers that can be easily transported. They normally have clam-shell construction with a fold-down lid that houses the screen, a keyboard, and any disk drives. They also have battery packs which provide power for a few hours' use (Collin, 2000). Although laptops are smaller (in size) than desktop computers, they have the same capabilities. They also run the same operating systems and can have large memories, great processing power, and can be connected to networks on the move through wireless technologies (Seppälä and Alamäki, 2002). Students can benefit from the capabilities and portability of laptops for in-class activities.

The discussion below provides an overview of the utilisation of portable devices in higher education in different settings.

2.2.1 Campus Wide Laptop Programs

Colleges and universities around the world are adopting campus wide laptop programs by providing students and instructors with portable/laptop computers. A study by Brown (2002) showed that there are approximately 140 institutions in the US, Canada, Japan, Netherlands, the UK and Australia undertaking campus-wide laptop programs.

A number of researchers – like Demb et al. (2004); Zelin and Baird (2002); McVay et al. (2005) - studied university laptop programs and their effect on both students and instructors. The studies found that laptops affected students' study habits and their academic and social lives positively. They found that computers helped with classroom assignments, communication and research. In addition, laptops encouraged collaborative learning between students when working on group projects and exploring class work with other students. Students felt their use of laptops was important to their academic success and had resulted in positive changes in their study habits. The studies also showed that laptops allowed students to learn at their own pace and integrate education into their daily schedules more effectively. This was because students could access learning activities, instructors, and each other anytime and anywhere. In these studies, the majority of students reported that they use their laptops outside the classroom for different purposes such as sending emails (personal and class purposes) and writing papers. Olsen (2001) argues that the greatest benefits of requiring students to have computers come from outside the classroom where students have 24-7 access to the Internet and the campus network.

However, studies found that the major factor that affects students' perception of the value of laptops to their academic success is their perception of the quality of faculty utilisation of the technology for teaching (Zelin and Baird, 2002; Demb et al., 2004). Students stated that academics did not utilise laptops effectively because they did not use them inside the classrooms nor encouraged students to use them outside the classrooms. Therefore, laptop computers can be better integrated in classrooms when academics embed technology in classrooms and pedagogy.

The following section explores some of the uses of portable devices (mainly PDAs and laptops) in higher education institutions. The section shows that the exploration and implementation of portable devices in education is not limited to institution-supported initiatives as in the campus wide laptop programs discussed above, researchers have also studied the utilisation of portable devices with case studies in different settings. The discussion is divided into two subsections: (1) research studies of portable computers in formal settings and (2) research studies of portable computers in informal settings. As discussed in Chapter 1, in this thesis, formal settings are defined as the locations where students' learning is directed by an instructor, other settings where instructors are not present are considered informal. Although portables utilisation in formal and informal settings are discussed in two separate sub-sections, some overlap appears in the discussion because, as Sharples (2000) argues, learning is not confined to the classroom, but moves more and more outside the classroom and into learners' environments.

2.2.2 Research studies of portable computers in formal settings

Several authors have discussed the uses of portables in formal settings in different subject areas. For example, Granberg and Witte (2005) studied the utilisation of laptop computers in social science classes. They compared different approaches to utilising laptops in classrooms. The first approach was to 'integrate' the use of laptops in classes by asking students to use them to take notes and access virtual classrooms that were always 'in session'. The aim was to allow students to exchange comments and questions during classes and search for relevant online resources in real time. The second approach was 'discrete' use of laptops where they had minimal impact on existing lecture materials and course designs. In this approach all lecture notes, class handouts and study guides were provided electronically. The goal was to encourage students to make regular use of their laptops and use them to complete exercises about concepts covered in the class. In most cases students used their laptops to complete exercises and especially search for online resources that help with class assignments' discussions. The study showed that students continuously used online resources to solve in-class exercises. This added immediacy and energy which students lacked when the same exercise was given as homework. The researchers reason that real-time Internet access gave students the chance to debate the issues as they arose. At the same time, solving in-class exercises using laptops improved students' critical thinking because students were in a position of choosing between good and bad online resources and discussing these resources' validity with other students, which helped them in obtaining evidence of their assessment.

Ryder (2000) described a study were all students and the instructor on a computer course, Computer Networking and Data Communications, were supplied with laptop computers to be used in the class to create computer networks by connecting laptops together. The typical computer course would usually be based on students listening to the instructor's illustration about networks and security and then returning to their dormitories to read and complete homework assignments on paper. Ryder argues that students found having laptop computers in classrooms is a great asset because it helps computer science students to practise computer activities which they may not understand until they have actually done them several times. However, the value of the findings of the study may be limited because of the lack of evidence of change in practice that might corroborate such opinions. This is caused by the researcher's reliance on students' self reports collected through students' reports that represented their notes of their utilisation of laptops for in classroom activities, homework activities, and other class activities. In addition, students' positive evaluation of the use of laptops in the course may be caused by their excitement about the use of new technology.

Portable devices have also been used in formal settings to facilitate students' participation. A number of researchers (e.g. Dufresne et al., 1996; Gay et al., 2001; Ratto et al., 2003) have studied the use of personal and wireless mobile devices to enable students to ask questions anonymously during lectures, create answer pools and give feedback on the class. Students and instructors could also view these lists and comment and answer the questions. For example, Ratto et al. (2003) developed an application (ActiveClass) that runs on PDAs provided to students and enables them to anonymously pose questions during lectures. The questions then appear on the instructor's laptop where he/she chooses whether to respond to them and at the same time gives students the chance to vote on the questions, providing the instructor with feedback on preferences. The researchers' intention was to encourage students' in-class participation. The study showed that giving students the opportunity to ask questions anonymously results in a broader range of questions being asked.

A similar study was conducted as part of the MOBIlearn project (Frohberg, 2005) where both students and the lecturer in an MBA class were provided with PDAs to be used during classes to (a) provide feedback through a voting system on the extent of students' satisfaction with the class performance to help instructors plan and adapt future lectures to students' needs, (b) enable sharing experiences, questions and anecdotes through a chat facility or forum that allows an entry to be linked to the relevant lecture slide and therefore associate it with the relevant context, and (c) support digital group work by providing collaborative group session software. The study concluded that portable devices helped with coordination between group members and sharing and contributing to each other's work, as well as building up a community that lasted longer than the MBA course.

Portable devices were also used by researchers (such as Campbell and Pargas, 2003; Demb et al., 2004; Weaver and Nilson, 2005) to support collaborative learning in higher education classrooms. The researchers argued that laptops provide new learning opportunities such as working under instructors' guidance; small groups working under controlled conditions; synchronous, whole-class activities like simulations; active-learning experiences that would be impossible in reality (e.g. dangerous or costly labs); and immediate exchange of, and feedback on, answers, solutions, and information.

Schaumburg (2001) also studied the effects of laptops on instructional strategies and classroom practice by providing both students and instructors with laptop computers and videotaping a number of classes with and without laptops being used. In addition, Schaumburg gathered data by interviewing and surveying students and teachers. He found that when laptops are used, the use of other instructional media such as textbooks and

worksheets, blackboards, and notebooks decreases. The amount of independent work was found to increase; while for other forms of instruction, such as teamwork, pair work, lectures and teacher-guided discussions, no differences were observed. Schaumburg's study contradicts other studies: Demb et al. (2004); Zelin and Baird (2002); McVay et al. (2005) that found that using laptops encourages collaborative learning and group work. The apparent contradiction can be due to the differences between the studies' methodologies as Schaumburg in addition to interviewing and surveying students (as was done in the other studies) observed students in classrooms. Moreover, differences in the participants' numbers, study time period, support provided for students and instructors, and the subject area may also be an influence.

To summarise, the discussion above shows that portable devices have been used in formal settings in higher education to support in-class activities such as viewing course/online material, writing/retrieving notes, solving classroom assignments and engaging in discussions and collaborative learning between students. Following is an overview on research studies of portable computers in informal settings.

2.2.3 Research studies of portable computers in informal settings

Portable devices are also used in education to facilitate learning activities and provide learning opportunities in informal settings. Sharples (2000) argues that learning takes place at various points in a person's life and is not confined to the classrooms of formal educational institutions. He also argues that portable devices are valuable tools for supporting informal and lifelong learning where people need to enhance their knowledge and skills continuously, in order to address immediate problems and to participate in a process of continuing vocational and professional development. Portable devices are suitable for this purpose because they facilitate 'anytime, anywhere' learning. In addition, they promote a socio-cultural approach to learning by enabling knowledge construction, ongoing conversation between learners, their peers and their teachers, and control over the process of learning, which according to Sharples is essential for the design of portable technologies that support lifelong learning:

> Effective learning involves constructing an understanding, relating new experiences to existing knowledge. ...Central to this is conversation, with teachers, with other learners, with ourselves as we question our concepts, and with the world as we carry out experiments and explorations and interpret the results. ... And we become empowered as learners when we are in control of the process, actively pursuing knowledge rather than passively consuming it. (Sharples, 2003, p. 506)

The definition of an informal setting in this thesis varies from the definitions available in the literature. An informal setting is usually understood by researchers (e.g. Sharples, 2000; Scanlon et al., 2005; Matthias, 2008) as outside traditional educational settings (out-of-school) where learners engage in practices that may be institutionally lead (e.g. school projects), leisure purposes (e.g. in museums or for tourism), fieldwork and support their hobbies (Scanlon et al., 2005). However, in this thesis an informal setting is understood as a location where students' learning is not directed by the instructor, even if this location is within the educational institution premises such as library, canteen, and lecture theatres.

Using portable devices to deliver learning materials and information resources has gained much interest in higher education. For example, Waycott (2002) studied the possibilities and constraints introduced by PDAs that can change the activity of reading course material. She conducted the study on an online Masters course offered by the Open University, where part-time students were given PDAs as a medium for reading course material. The study found portability to be the main benefit. The small and lightweight devices made reading easier to fit around other activities. Thus, the accessibility of course material anytime and anywhere changed the way students undertook reading. However, the limitations of the devices restricted their usability. Students found that the small screen size and poor screen quality limited reading activities, in which they had to adopt a line-by-line reading strategy making scan-reading of the documents difficult. Moreover, students found it difficult to take notes about course materials on the PDA using the handwriting recognition system, which was slow and error-prone. The study also found that PDAs did not replace the tools students usually used to support reading; instead it was used in conjunction with printed course materials and desktop computers. However, the findings of the study may be limited as the data was mainly collected through self report methods (interviews and questionnaires) which were not validated/triangulated by other accounts of data. This affects the accuracy and validity of the findings.

In another study, medical students from the University of Oslo were supplied with PDAs to be used during their practical training in hospitals to access an electronic book of their main reference text, use email and download material from the internet (Lundby, 2002). The study aimed to provide students with instant access to information resources when and where needed such as when diagnosing patients or working collaboratively with fellow students. However, students rarely used the PDAs as they used other artefacts such as reference books instead of the electronic book that was downloaded on the PDA and was specifically prepared for students' 'just-in-time' access to information. This was mainly due to the PDAs' usability problems such as the small screen size and the fact that the electronic book did not carry

many of the properties of paper-based artefacts. Another difficulty that students faced was working across different applications and information resources on the PDA which limited using the device for communication purposes. The only feature that students found useful was the SMS (Short Message Service) which was heavily used to arrange social events (Smørdal and Gregory, 2005).

Portables have also been used in higher education as learning organisers because they provide time management (e.g. calendars) and communication tools (e.g. instant messaging) as well as the capability to access, store and retrieve learning resources. Corlett et al. (2005) conducted a study that investigated whether students would find a handheld computer (PDA) with specially designed integrated learning organiser useful for supporting their learning. In the study, students enrolled in a Masters course were provided with wireless PDAs that integrated a mobile learning organiser. The mobile learning organiser involved an integrated suite of tools to help students' learning such as accessing course materials; viewing timetables; communicating through emails and instant messaging; and organising ideas and notes. The study found that students made considerable use of the calendar and timetabling features as well as the communication tools. Students also used the provided course materials and suggested that more content could be delivered this way. Corlett et al. (2005) also found that although there was no indication that the organisers altered students' styles or patterns of learning, they had some impact on the way students worked. However, similar to Waycott's (2002) study discussed above, the data in this study lacks accuracy as it was based on students' self reports, collected through questionnaire surveys and focus groups, and was not triangulated with data that reflects students' actual use of the technology.

Moreover, portable devices have been used to provide location-based experiences to students as they enable students equipped with portable devices such as PDAs, laptops, mobile phones, and gaming consoles, to move about in the world while sensors capture their availability and location and provide them with experiences that change according to their location, the activity they are engaged in, and even their feelings, 'mood' or 'intention' (Vogiazou, 2002; Benford, 2005). These experiences help users experience digital media throughout the day regardless of their location and time. The personal nature of portable computers and their adaptability to environments make the devices a good choice for these experiences.

Higher education institutions benefit from location-based experiences in enhancing on-campus learning while at the same time extending their reach to distance and part-time students. Location-based experiences also enhance the opportunities of higher education institutions to accommodate the needs of the increasing and more diversified student

populations and to reach learning activities outside the traditional campus setting (Roussos, 2002). In addition, they allow learners to engage in personalised learning experiences, and give them ownership and increased access to learning materials when and where they are most relevant, hence encouraging responsibility for their own work (Naismith et al., 2005). However, location-based experiences raise serious privacy concerns (i.e. social and organisational challenges) when users' movements are stored centrally 'in the network' and might be accessed by others. At the same time, some people might find it intrusive because they cannot concentrate on specific tasks or separate different aspects of their lives (Benford, 2005).

Location-based applications are used in education as information providers and guides. They can be used to provide students with information while moving in the campus based on their current location. For example, the Active Campus Explorer is a location-based information and guide service developed by University of California at San Diego to provide residents with location-based links to web pages and opportunities for social contact (Griswold et al., 2002). Location-based audio guides are also used inside museums and galleries to provide students with information while they are moving throughout the place (Benford, 2005).

Location-based experiences are also used to create collaborative games that extend across a series of locations. In these games, students need to move through the physical world in order to be able to play (Benford, 2005). For example, NESTA Futurelab and Hewlett-Packard Laboratories developed an educational game called 'Savannah' which teaches children about the African Savannah and especially about the behaviour of lions. A group of six children were provided with handheld computers equipped with location sensing and were asked to role-play being lions and explore a savannah that is actually an empty school playing field. Children could move around the playing field, exploring the varied terrain of the savannah and discovering the resources that lions need to survive (Facer et al., 2004).

Moreover, location-based technologies can be used in students' field visits, whether scientific or historical. These technologies are used to offer students with information in context, such as uncovering a complex history or ecology as they are exploring the place. For example, Ambient Wood is a project by UK's Equator Interdisciplinary Research Collaboration in which children use wireless sensors and displays to explore and reflect upon a physical environment (ecology of a woodland) that had been augmented with digital abstractions (Price et al., 2003; Weal et al., 2003).

Furthermore, location-based applications can be used in field sciences to provide students with help in collecting data from the field. Field science can be used to support scientists by providing them with easy ways to work both around the laboratory and away in the field. Providing scientists with mobile sensors helps them to take readings and measure where these readings were taken. The readings then can be logged in a portable device and uploaded to a common data repository (Benford, 2005).

In conclusion, the discussion above shows that portable devices are used in informal settings to provide students with learning opportunities; access to learning materials and information; and means of communication and collaboration. Although some of the examples discussed above were not implemented in higher education, they are used here to elaborate on the use of portables in informal settings in general. The next section aims to provide an overview of the main theme of this thesis: mobile learning.

2.3 Mobile Learning

Interest in mobile learning goes back to the 1970s when Alan Kay at Xerox Palo Alto Research Center (PARC) wanted to make computing technologies accessible for children and useful in an educational context. Kay is considered as one of the first researchers who recognised the potential of mobile learning and the use of portable computer technologies in education. He argues that since learners are mobile, educational technologies should also be mobile (Kay and Goldberg, 1981). In addition, learning has always been a mobile activity mediated by the use of portable tools such as books and pens. Kay designed a personal dynamic medium at the size of a notebook (the Dynabook) that could be owned by everyone and has the power to handle all of its users' information-related needs. The device was envisioned to include flat panel display and wireless communications with software that facilitates dynamic interactions between the learner and the device (Kay, 2004). However, Dynabook development did not proceed beyond the prototype phase mainly due to technical complications related to required hardware and software. Nevertheless, its concepts defined the basics of today's laptops and tablet computers. Kay (ibid) argued that despite the recent success of laptops and handheld computers, these tools did not support learning activities in the way he had imagined for the Dynabook especially in terms of the relationship between the computer and user. He argues that what is 'most significant about the idea of the Dynabook lies in the constructions that people, especially kids, can do with it, and which they can't do in any other way', where the devices encourage independent learning and students could explore, construct and share their own applications (e.g. games and simulators) (Kay, 1972).

In the last ten years, mobile learning has gained massive attention in the field of educational technology. Research in the field has focused on exploring the utilisation of portable technologies to facilitate and enhance learning experiences in formal and informal settings and the methodological issue of conducting such studies. The interest in studying mobile learning was not limited to the field of educational technology; it also resulted in the rise of research in other fields like Human Computer Interaction (HCI) (Holme and Sharples, 2002; Sharples et al., 2002; Cacace et al., 2004). This led researchers from multiple disciplines to get together and explore related issues and solve common problems especially in terms of contextualised and collaborative learning experiences and developing futuristic technologies that are more adaptable to the broadening context of learning in the mobile age.

The interest in mobile learning research in educational technology is reflected in the number of special issues of journals (e.g. Hoppe et al., 2003; Roschelle et al., 2005; Sharples, 2007) dedicated to explore different aspects of mobile learning. In addition, a large number of annual conferences has been established which aim to explore and disseminate research in relation to mobile learning such as mLearn, IADIS International Conference Mobile Learning, Handheld Learning Conference, and Wireless, Mobile and Ubiquitous Technologies in Education (WMUTE). Moreover, numerous projects in schools (e.g. Learning2Go in schools in Wolverhampton; Perry (2005)), higher education (e.g. mobile learning organiser at the University of Birmingham; Corlett et al. (2005)), museums (e.g. MyArtSpace; Sharples et al. (2007b)), and cities around the world (e.g. using SMS to support learning in Sub-Saharan Africa; Traxler and Dearden (2005)) have been established to study the utilisation of portable devices in different settings and for different purposes. The interest in mobile learning is also reflected in government funding which aims to develop schools for the future by providing students and teachers with portables and exploring the possibilities and constraints these tools provide in different learning contexts. For example, in the UK, the government invested about £2.2 billion in 2005-06 in the Building Schools for the Future (BSF) program which aims to ensure that secondary pupils learn in 21st-century facilities. The project also provided about £3 billion in 2005-06 to supply local authorities and schools with sufficient funds to spend on maintaining and improving their school buildings and the quality of provision (DCSF, 2008). Furthermore, there are large numbers of projects that aim at exploring the utilisation and opportunities provided by portable devices in different areas of life. For example, the MOBILearn project was a 30 month, €7.5 million, worldwide European-led research and development project aimed at exploring 'new ways to use mobile environments to meet the needs of learners, working by themselves and/or with others in groups' (MOBIlearn, 2005, p. 7). Some primary research institutions also contributed to the discussion and development of the field of mobile learning, such as NESTA Futurelab,

Learning Skills Development Agency (LSDA), and the British Educational Communications and Technology Agency (Becta).

The increasing interest in introducing portable devices in education encouraged many researchers to seek a better understanding and develop theories and conceptualisations of the new phenomenon of mobile learning. The following section discusses current efforts to conceptualise mobile learning and provides an overview on the complexity and fragmentation of work in the field.

2.3.1 Definitions of mobile learning

The review of researchers' attempts to conceptualise mobile learning showed that researchers define the term in a variety of ways. Some focused on the mobility of the devices and hence developed techno-centric definitions. In these definitions mobile learning is characterised as learning using mobile devices such as PDAs or mobile phones. For example, Kukulska-Hulme et al. (2005) define wireless and mobile learning as 'learning delivered, enhanced or supported mainly or solely by wireless and mobile devices and their technologies'. However, the researchers admit that the definition is limited as it places great emphasis on the technology and too little on learning. They called for a definition that focuses on the learning and the experiences of the learner. Lehner and Nösekabel (2002, p. 103) share the same emphasis. They defined mobile education as 'any service or facility that supplies a learner with general electronic information and educational content that aids in the acquisition of knowledge regardless of location and time'. In addition, Sharma and Kitchens (2004) defined mobile learning as learning that is supported by mobile devices, ubiquitous communications technology, and intelligent user interfaces.

However, as Kukulska-Hulme et al. (2005) point out, these definitions are limited as they focus more on the technology than on learning itself. In addition, they ignore learning that is not mediated by the use of portable technologies or learning that is mediated by traditional devices such as handouts even when, intuitively, this might be classified as mobile. O'Malley et al. (2003) (discussed below) share the above emphasis as the researchers argued that mobile learning is any sort of learning that happens when the learner is not at a fixed, predetermined location. Their definition discards the properties and type of device used to facilitate learning and focuses on the mobility of the learner rather than the mobility of the used devices. However, the researchers still argue that the employment of certain types of technology is what differentiates mobile learning from other types of learning; in spite of their theoretical position they retain their technical emphasis.

Other researchers defined mobile learning as an extension to e-learning. For example, Quinn (2000) defined mobile learning as 'elearning through mobile computational devices: Palms, Windows CE machines, even your digital cell phone'. He describes his vision of mobile learning as the intersection of mobile computing and e-learning where people have access to resources, search capabilities, rich interaction and support for effective learning and performance-based assessment. Quinn visualises mobile learning as 'elearning independent of location in time or space'. In addition, Traxler (2005) defines mobile learning as 'any educational provision where the sole or dominant technologies are handheld or palmtop devices'. He argues that the definition 'merely puts mobile learning somewhere on e-learning's spectrum of portability'. Although these definitions look at e-learning provision, they remain techno-centric as they focus on the type of device used. For example, Traxler admits that his definition is limited as it is 'rather techno-centric, not very stable and based around a set of devices'. In addition, these definitions are limited because they are based on the definition of e-learning which itself is difficult to conceptualise. That hinders identifying the unique nature of mobile learning.

When these definitions, both techno-centric and those based on e-learning, are applied to real-world examples, many borderline cases where learning cannot be defined as mobile or static appear. This is because these definitions are based on the assumption that mobile learning occurs as a result of using portable technologies to aid learning in different physical locations. The definitions are focused on the technology rather than the learning practices that are mediated by the technology. They also discard all learning that is not mediated by the use of portable technologies. In addition, the definitions place overt emphasis on the change of physical location while discarding the social setting of learning activities. This point was addressed by Roschelle (2003), who illustrated the importance of understanding the social practices involved in using handheld devices to facilitate learning. He reviewed a number of studies that explored the use of handheld devices, such as classroom response systems and their application in classrooms. A classroom response system allows a teacher to pose a question (e.g. short-answer or multiple choices) and collects and aggregates students' responses sent by individual handheld response units. The review showed that using portable devices does not make learning mobile as the activity space of technology usage is the classroom space (Roschelle and Pea, 2002). Portable technologies in the reviewed cases were used during the class to achieve certain objectives and some could not be used outside the classroom (e.g. classroom response systems). Roschelle argues that the case studies failed to establish a link between informatics and social practices as the researchers in the reviewed studies provided little insight into the social practices of handheld use presuming that the social practices surrounding education remain largely unchanged as the technology moves

from desktops to handhelds. He suggests that research attention should be directed towards 'understanding the social practices by which those new affordances become powerful educational interventions' (Roschelle, 2003, p. 19).

Some researchers have considered social practices surrounding learning activities to develop their conception of mobile learning. These researchers' conceptualisation of mobile learning also started as techno-centric definitions focusing on devices (Sharples et al., 2002) and the potential for enabling lifelong learning (Sharples, 2000). Soon, however, the focus became the learner, who is mobile, rather than the technology. For example, O'Malley et al. (2003, p. 6) defined mobile learning as 'any sort of learning that happens when the learner is not at a fixed, predetermined location, or learning that happens when the learner takes advantage of learning opportunities offered by mobile technologies'. In addition, Vavoula and Sharples (2002, p. 152) consider learning to be mobile in three ways:

> in terms of space, i.e. it happens at the workplace, at home, and at places of leisure; it is mobile between different areas of life, i.e. it may relate to work demands, self-improvement, or leisure; and it is mobile with respect to time, i.e. it happens at different times during the day, on working days or on weekends.

These definitions diverted the focus from the technologies used to the mobility of the learner and the context of usage that extends learning to informal learning settings. This also reflects on the original intention of the Dynabook.

Sharples et al. (2007c, p. 224) proposed a definition of mobile learning that focuses on the communicative interactions between the learner and the technology to advance learning in a context that is shaped by continuously negotiated dialogue between people and technology. They defined mobile learning as 'the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies' which they described as a tentative definition. Their definition was based on a theory of mobile learning they developed (discussed in Section 3.1) which is based on the conversational framework (Laurillard, 1993), discussed in Section 3.2, and Engeström's (1987) expansion of activity theory, discussed in Section 3.4. The conversational framework was used to account for the communicative interactions between the learner and the technology. This was chosen because the conception of learning here is based on the idea that communication, which is a feature of portable devices, is a central process in education as it helps people to negotiate their differences, understand each others' experiences and establish shared meaning. In addition, activity theory was used to study mobile learning in relation to the context of learning activities. The researchers conceptualised the context of learning as both the physical

environment and the community (including both people and interactive technologies) that interact around shared objectives.

Sharples et al.'s (2007c) definition of mobile learning represents a useful first step towards a better conceptualised definition of the term. The definition focuses on learning through conversations that take place across different contexts (rather than locations as in some of the previous definitions of the term). Critically, Sharples et al. conceptualised context as the physical environment and the community that interacts around shared objectives. This conceptualisation helps with considering the community as being engaged in learning activities and the influence of these practices on learning. This gives a new perspective on mobile learning by considering influencing factors other than location.

The discussion above showed that although mobile learning is a popular research area, it is not well conceptualised. This is mainly due to the complexity caused by the fragmentation and diverse perspectives in research in the field. The conceptualisation of mobile learning is considered one of many issues that require exploration by researchers in the field. Winters (2007) constructed a concept map (shown in Figure 2-1) that addresses the key characteristics of mobile learning which are required for re-conceptualising the term. In the concept map, mediated learning is considered the centre instead of mobile learning as Winters believes that the emphasis should not be on the type of device used. Instead the focus should be on learning, which can be mediated by a number of factors such as context, cultures, tools, learning activity, etc. This enables viewing learning from a particular perspective, which then helps in characterising the unique dimensions of mobile learning. The concept map also shows that technology takes a secondary role because the choice of technology is affected by the social factors and learning activities. The figure also shows the diversity and complexity of mobile learning which ranges from studying the tools used to mediate learning activities, to studying the type of learning activities, and the cultures engaged.

Figure 2-1 Mediated learning through mobile technologies (Winters, 2007)

In this thesis, the concept 'mobile learning' is to be explored in depth drawing on the current conceptions informing the field offered by different researchers. This will help other researchers to develop a better informed interpretation of mobile learning.

2.4 Conclusion

In this chapter, the literature that examined the use of ICT as a learning tool has been reviewed. It was shown that a number of forces (internal and external) motivate higher education institutions to adopt technology in teaching and learning. For example, the continuous technological developments encouraged higher education institutions to provide new technologies for both instructors and students, which then affected how instructors teach and students learn. The successful implementation of technologies in education requires effectively integrating technologies in education by embedding the technology in educational practices in general where students and instructors use the technology to accomplish routine practices. However, this faces a number of barriers which obstruct the integration of technology in education. These barriers are related to the instructors' lack of computer training, instructors' attitudes toward the technology and students' resistance towards the new technology.

The chapter also reviewed recent research that has examined the use of portable technologies (especially PDAs and laptops) as learning tools. The studies showed that these devices are

utilised in a wide range of learning settings (formal and informal) and have potential value for students' learning as they enable learning anywhere, anytime to facilitate processes such as fieldwork, in-class activities and collaborative learning activities.

The chapter showed that the reviewed studies typically involved distributing portable devices among students and gathering their perceptions about the educational uses of the devices through interviews and surveys. These studies lacked the analysis of students' actual and routine use of portables, because these were introduced to students during the study, which made students adjust their practices to use the devices. In addition, most of the studies were based on students' perceptions of using portable technologies gathered through self report methods. Students' responses were not examined against their actual use of the technology, which is important as students' responses may not be accurate, complete or honest.

Furthermore, the review of the literature showed the importance of studying students' learning activities in relation to the context where these take place. An important factor that the students in the reviewed studies found to affect their utilisation of portable technologies was their instructors' level of technology utilisation (Zelin and Baird, 2002; Demb et al., 2004). Students complained about their instructors not using the technologies in teaching and not encouraging students to use them. Most of the reviewed literature did not consider the effect of instructors' technology utilisation on students' technology utilisation. This thesis will explore this issue. The exploration of the relationship between context and learning activities will also include an investigation of the relationship between context and patterns of communication in formal and informal settings.

Finally, it has been shown that although mobile learning is a popular current research topic, it is not well conceptualised. Many researchers rely on under-theorised conceptions of the topic, and those who have tried to refine the ideas involved have found this to be complex and difficult. Some researchers have taken techno-centric positions focusing on the mobility of the used devices (e.g. Lehner and Nösekabel, 2002; , 2004; Kukulska-Hulme et al., 2005), others viewed mobile learning as an extension to e-learning (e.g. Quinn, 2000; Traxler, 2005), and some have taken the context of use as the basis for their definitions (e.g. Sharples et al., 2007c). Because of these ambiguities, this thesis aims to explore and conceptualise the concept of 'mobile learning' through empirical studies that investigate students' utilisation of portable devices in multiple formal and informal settings.

Thus, the review of the literature has helped to address the research questions, outlined in Chapter 1, by investigating issues around mobile learning, the use of portable technologies

(PDAs and laptops) as educational tools, and the relationship between context and practice. In addition, however, it has highlighted new questions. As a result, the research questions that this thesis aims to answer are:

1. What is mobile learning?
2. How do students in Higher Education utilise portable technologies in formal and informal settings?
    - How does the use of portable technologies differ when they are supplied as part of a study, rather than when they are used by students as part of their routine study practices?
    - What is the influence of portable technologies on Higher Education students' educational practices?
3. What is the relationship between context and students' learning activities?
    - What is the impact of instructors' portables use on students' utilisation of portables?
    - What is the impact of context on students' communication?

Chapter 3

Theoretical Background

As already established, this thesis aims to develop a conceptualisation of mobile learning through empirical studies that investigate students' utilisation of portables (old and new) in multiple contexts (formal and informal). This section discusses the theoretical background of the research that was utilised to achieve the goal of this thesis. The chapter begins by discussing previous attempts to theorise mobile learning. Then, the conversational framework is reviewed with a discussion of the reasons behind not using the framework in this thesis. This is followed by a discussion of the notion of context and its relationship to students' learning activities. After that, activity theory is reviewed by discussing its central concepts that inform this research.

3.1 Theorising mobile learning

Sharples et al. (2007c) argue that there are many theories of learning but none have focused on the mobility of learners and learning. Thus, the researchers proposed a theory of learning for the mobile age that addresses the relations between mobile technology and learning. They sought a theory that covers both learning supported by mobile devices and learning that is characterised by mobility of people and knowledge. The researchers suggested that the theory requires:

1. Re-conceptualising learning for the mobile age through conceiving education as conversation in context that is enabled by continued interaction through and with personal and portable technologies.
2. Recognising the essential role of mobility and communication in the process of learning where portable devices enable certain forms of communication which students adapt for their communications and learning activities such as phone conversations, email and instant messaging.
3. Indicating the importance of context in establishing meaning and the transformative effect of digital networks in supporting virtual communities that rise above barriers of age and culture.

They argue that in order to create a theory of mobile learning, first, mobile learning should be distinguished from other forms of leaning activity by showing that learners:

1. Learn across space as they take ideas and learning resources gained in one location and apply or develop them in another.

2. Learn across time by revisiting knowledge gained earlier in a different context which then provides lifelong learning.
3. Move from topic to topic by managing a range of personal learning projects instead of following a single curriculum.
4. Move in and out of engagement with technology.

These points are referred to as Sharples et al.'s (2007c) mobile learning properties (MLP) throughout this thesis. The researchers argue that distinguishing mobile learning from any other form of learning does not mean separating it, because some aspects of informal and workplace learning are fundamentally mobile. Rather, they suggest analysing learning practices by focusing on the mobility of learning to understand how knowledge and skills transfer across contexts. Second, Sharples et al. argue that a theory of mobile learning must incorporate the considerable learning that occurs outside the classroom and lecture halls. Third, it must be based on contemporary accounts of practices that enable successful learning. Fourth, they suggest that the theory must take account of the ubiquitous use of personal and shared technology.

As part of developing a theory of mobile learning, Sharples et al. (2007c) introduced a framework for analysing mobile learning based on Engeström's (1987) expansive activity model (both discussed in Section 3.4). However, the framework was illustrated through a case study whose criteria were chosen from the data. Their illustration was descriptive rather than analytic as they did not test their framework against other real-world cases that do not match the framework exactly. In the case, a group of participants were supplied with portable devices during their visit to the Uffizi Gallery in Florence. The participants walked around the gallery inspecting the paintings and using their devices to get more information about the paintings and communicate with other participants. The case was chosen to reflect the four mobile learning properties (MLP) discussed above which were proposed by the researchers as a basis for the theory of mobile learning. The case represents learning that occurs in an informal learning setting (gallery; second criterion) where visitors were supplied with the portable technologies (fourth criterion) to be used throughout their visit (first criterion). Portables were used to look for information about the paintings in the gallery and to communicate with each other (third criterion). According to the researchers, the case represents mobile learning as learners used their devices to learn across space, time, move from topic to topic and move in and out of engagement with technology.

As mentioned earlier, this thesis aims to develop a conceptualisation of 'mobile learning'. The starting point for this thesis was to work with Sharples et al.'s mobile learning properties by

using them to analyse real-world case studies documented through empirical studies that investigate students' utilisation of portable devices in different contexts. Sharples et al. (2007c) argued that the properties can be used to distinguish mobile learning from any other type of learning activity. Using the properties to analyse the research data thus intended to provide evidence as to whether to accept the theorisation of mobile learning that Sharples et al. proposed or introduce a new conceptualisation. It is important at this point to highlight that the discussion in this thesis builds upon Sharples et al's written proposal and associated publications (Sharples, 2005; Sharples et al., 2005; Taylor et al., 2006; Sharples et al., 2007a; Sharples et al., 2007c).

3.2 The Conversational Framework

The conversational framework, developed by Laurillard (2002), is based on the conversation theory developed by Pask, Scott and others across three decades to study communication and its effect on learning. Scott (2001) argues that Pask's (1976) conversation theory posits that learning occurs through conversations about a subject matter which serve to make knowledge explicit. The conversational framework provides clearly formulated pedagogic principles that help show how to deploy technologies to meet particular educational objectives. It also provides a set of concepts and principles concerning human systems and their organisation which can help educational technologists and others appreciate and address the administrative, political and cultural implications of the new technologies.

The conversational framework represents teachers and students as interacting through some medium (e.g. face-to-face tutorial, correspondence, or employing a combination of several media). Laurillard stresses that the interaction between students and teachers must take place at both the theoretical (description) and practical (action) levels, which enables students to link theory to practice and allows teachers to evaluate whether or not the tasks were appropriate for students.

Sharples et al. (2007c, p. 224) consider the communicative interactions between learners and technology as an important factor when they defined mobile learning as 'the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies'. They argue that communication, which is a feature of portable devices, is a central process in education as it helps people to negotiate their differences, understand each others' experiences and establish shared meaning. They used the conversational framework to study communication and its effect on mobile learning.

According to Sharples (2005), students not only benefit from formal education, they are also becoming more aware of the opportunities offered by mobile communications and online communities for their informal learning. Students increasingly interact outside the classroom using mobile calls, texting, computer messages and online communities. Sharples (2005) argues that technologies may enrich the environment in which conversations take place by providing tools for collecting data and for building and testing models. They can also extend the range of activities and the reach of discussion through games and simulations by mobile phone or email. Portables provide a shared conversational learning space, which can be used not only for individual learners but also for learning groups and communities. The technology can also demonstrate ideas or offer advice at the level of description, as with the World Wide Web or online help systems, or through specific tools to negotiate agreements, such as concept maps and visualisation tools.

However, although it is relevant to mobile learning research, the conversational framework was not used in this thesis. This is because it focuses on studying communication, represented in the framework as the interactions that occur between the technology and the student at both the theoretical and practical levels of learning, and the *impact of this on students' learning*. This thesis does not aim to investigate this issue. As already discussed, this thesis does not focus on exploring if and what students are learning, which the conversational framework would help in exploring; rather, it focuses on investigating *how students use tools to accomplish learning activities in and across multiple contexts*. Activity theory is an ideal framework (1996) to be used for that as it enables studying the utilisation of technologies as mediating tools to undertake learning activities. It also enables studying learners' activities in relation to the context where these are situated. In addition, activity theory helps in providing an historical perspective on students' learning activities which is essential for studying mobile learning. Most importantly, neither context nor history are explicitly represented in the conversational framework. Moreover, activity theory enables studying communication, which is an important feature of portable devices, as an example of an activity. Thus, it still permits communication to be investigated to some degree. As a result, the conversational framework was not used to conduct this research because it was less relevant to what the research aims to study. More about the relevance of activity theory for this thesis is discussed in Section 3.4.

3.3 Context and Learning

Studying the relationship between context and students' learning activities that are mediated with the use of portable devices plays an important role in this thesis which builds on the assumption that students' learning activities occur in multiple formal and informal contexts.

Leont'ev (1978) suggests that in order to understand humans' activities it is crucial to understand how artefacts (such as tools and symbol systems) mediate the activity within the cultural context in which the activity is situated. Tolmie (2001) argues that the same technology may have unexpectedly diverse effects, according to the specific setting in which it is employed. This is because of the variation in the context of educational and social activity in which technologies are employed which then affects learning activities. This shows that context has an impact on the use of technologies which in turn affect students' learning activities. For example, Tolmie and Howe (1993) studied the impact of students' context by comparing groups of matched and mixed gender students learning through educational software. They concluded that there is a need to adopt a context-sensitive approach to the introduction and the evaluation of ICT in education, in order to discern and subsequently manage its real impact.

The concept of context has been a source of confusion for Anglo-American psychologists. However, over the last decade, psychologists have come to distinguish between two general uses of the word. For example, Cole (1996) distinguishes between context as 'that which surrounds us' and context as 'that which weaves together'. In terms of the interactions between humans and technology, these definitions map context as that which surrounds the human user of the technology and context as that which arises from the constructive interaction between people and technology.

The context that surrounds the human user of the technology is roughly equivalent to the term 'environment', and refers to a set of circumstances with which the individual interacts and which influences individuals in various ways (Cole, 2003). This is often represented as a set of concentric circles representing the different levels of context. For example, a student using technology is part of a lesson that is part of a classroom that is part of a university that is part of a community (Cole, 1996). Understanding activities in relation to the environment where they take place helps with understanding how the task is shaped by the broader levels of context. In terms of the impact of context on learning activities, Sharples (2005) refers to the informational model of communication developed by Shannon-Weaver. The model states that the context that surrounds the human user of technology situates the learner in an environment from which the senses continually receive data that are interpreted as meaningful information and employed to construct understanding.

The context that arises from the constructive interaction between people and technology can be thought of as two moments in a single process that help in modifying objects to create supportive workspaces, or forming ad hoc social networks out of people with shared interests

(Cole, 1996). This definition of context is more focused on the social setting of the learning activities and not only affects learning activities, but is also affected by these activities. Cole (2003) supports that definition by drawing on Vygotsky's view on context: seeing humans as an embedded part of the social matrix so that their behaviour cannot be understood independently from this matrix.

The complexity of understanding context has started to feature in research on the design of technology. For example, Dourish (2004) argues that 'context' plays a central role in ubiquitous computing, where computing is embedded into the world around us. He suggests that as computation has moved 'off the desk', it is important to keep track of where it has gone as the situations in which the technology is used became more variable and require further attention.

Dourish argues that since 'context' entered the area of computational design, designers have hoped that incorporating context into interactive technologies can make these technologies more sensitive to the details of specific setting of use. He reports Suchman's (1987) critique that social scientists have often pointed out that conventional system designs fail to respond to the setting in which action unfolds. These conventional systems may be more responsive to the different social settings in which they might be used, but they fail to address the sociological critique which makes turning social observations into technical design problematic.

Dourish suggests that the notion of context in ubiquitous computing has a dual origin.

> On the one hand, it is a technical notion, one that offers system developers new ways to conceptualize human action and the relationship between that action and computational systems to support it. On the other hand, it is also a notion drawn from social science, drawing analytic attention to certain aspects of social settings. (Dourish, 2004, p. 21)

In conclusion, current conceptions of the term context, both in social and technological research, tend to separate the features of the environment where learning takes place from that of the social setting of the learning activities. This raises a question about which understanding of 'context' is most useful to understand learners' activities that take place in multiple locations and specifically studying mobile learning. The conception of context that is used in this thesis is illustrated in Section 3.4.

3.4 Activity theory

This section discusses the central concepts of activity theory that are relevant to this research. It also explains how these concepts can be used to answer the research questions specifically studying and conceptualising mobile learning, which is the main theme of this thesis. These concepts are summarised as follows:

1. Activities are sociocultural systems that consist of the subject (a student) whose actions are directed towards the object (goal) of the activity through mediating tools (physical and conceptual) within a community that is engaged in achieving the objective (object) of the activity and is governed by rules and division of labour.
2. Activities are in constant development and transformation.
3. Activities can be divided into hierarchical layers of actions and operations which evolve over time.
4. Activity systems develop by the introduction and resolution of the contradictions that occur within and between these activities.

The points above were used to understand students' learning activities in multiple contexts and investigate how students use their portables to mediate their learning activities within these contexts. The points also enabled studying the relationship between context and learning activities that are mediated by the use of tools and understanding mobile learning.

3.4.1 Activity Theory – an introduction

Activity theory was developed as an attempt to create a new form of psychology based on Marxist philosophy (Leont'ev, 1978; Vygotsky, 1978). Kuutti (1996, p. 25) defined Activity theory as: 'a philosophical and cross-disciplinary framework for studying different forms of human practices as development processes, both individual and social levels interlinked at the same time'.

The foundation of Activity theory or the 'cultural-historical theory of activity' was developed by the Russian psychologist Vygotsky. Although he did not develop the full set of concepts of the theory, Vygotsky is considered the founder of activity theory (Wertsch, 1985). The theory is based on Vygotsky's (1978) idea of tool mediation: that all human activities are mediated by the use of tools, both physical such as technology and conceptual such as language, which enable and limit activities. Figure 3-1 shows the mediation aspect of human activity. Vygotsky's ideas were then developed by Leont'ev and others who started to use the term activity (Kuutti, 1996). In Leont'ev's (1978) version of activity theory, activity is viewed as a hieratical structure that consists of actions and operations. This is discussed further below.

The theory was further developed by Engeström (1987) who used Vygotsky's (1978) concept of tool mediation and Leont'ev's (1978) notion of activity to describe activity as an expansive social setting under constant transformation. Engeström also used the Marxist concept of contradictions to understand and highlight the factors behind the development of social systems.

Activity theory is often used in educational technology and Human Computer Interaction (HCI) research (e.g. Bodker, 1996; Kuutti, 1996; Nardi, 1996; Nardi and Kaptelinin, 2006) because it provides a conceptual framework for understanding the structure, development, and the context of computer–supported activities (Kaptelinin and Nardi, 1997). However, using activity theory for research is challenging because the theory was developed in Russian, German, and Scandinavian languages and has undergone many translations which led to different conceptions of the basic abstraction of the model. For example, the notion of an 'object' which usually encompasses a physical object in the English language, also encompasses the concept of an objective (Nardi, 1996, p. 73) which represents the motive of the activity. As a consequence, using activity theory for research requires, first, understanding and clarifying how certain terms will be used.

Second, activity theory is complex and requires considerable learning and experience (Rogers, 2004). This is because its concepts were mainly developed by Vygotsky who was less interested in supporting his ideas with empirical studies (Cole, 1996). His concern was mainly to establish basic principles of his theory and method and opening new lines of investigation. Thus, using activity theory concepts is difficult because of the lack of statistical tests or raw data on which to base records and observations. This makes activity theory not a fully developed theory, but a framework from which several ideas, theories and methods for conceptualising human practices (activity) in relation to tools emerge (Mwanza, 2002). Unlike grounded theory which provides researchers with a set of steps to follow in order to develop theories, activity theory does not provide researches with guidelines for operationlising its concepts. Engeström (1993, p. 64) also argues that activity theory is not 'a fixed and finished body of strictly defined statements - it is itself an internationally evolving, multivoiced activity system'. It consists of a set of principles that are open to interpretation and can be used as a foundation for more specific theories (Kuutti, 1996). This imposes another barrier on using activity theory for research as different researchers tend to use activity theory in different ways (Bellamy, 1996; Issroff and Scanlon, 2002), while others attempted to extract a set of research methods for activity theory (Kaptelinin et al., 1999; Mwanza, 2002). However, these attempts cannot be replicated for other research because of the differences in the research objectives and settings, and therefore differences in the

interpretation of activity theory concepts which were tailored for the specific research objectives. Thus, as Engeström (1993, p. 97) argues, activity theory should be *concretised* to serve the particular research that is taking place rather than standardised.

> Activity theory is not a specific theory of a particular domain, offering ready-made techniques and procedures. It is a general, cross-disciplinary approach, offering conceptual tools and methodological principles, which have to be concretized according to the specific nature of the object under scrutiny.

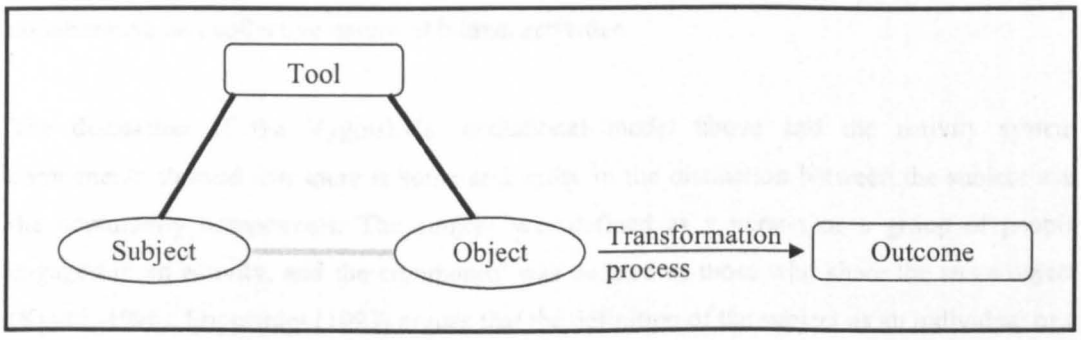
Therefore, this thesis offers the researcher's interpretation of the main concepts of the theory which are concretised to achieve the purpose of this research; these are discussed below. It is worth highlighting that although these concepts are discussed separately, this does not suggest the supremacy of one concept over another nor that these concepts can be understood in isolation from one another; they are interconnected.

3.4.2 Tool mediation

The concept of tool mediation is one of the central concepts of activity theory. It is based on Vygotsky's (1978) notion that all human activities are mediated by the use of tools. Vygotsky considers tools as the means by which humans change nature and by doing so transform themselves. He extends the definition of tools to involve both physical tools such as artefacts, which are intended to manipulate physical objects, as well as psychological tools such as language, which is used to influence behaviour or other people. Mediating tools can be both enabling where they help in transforming and manipulating different objects, and limiting as objects are manipulated and perceived within the limitations set by tools. Mediating tools are affected by the social and cultural settings of use where they are considered carriers of cultural knowledge and social experiences (Kaptelinin, 1996).

Vygotsky's 'mediational model' shown in Figure 3-1, illustrates human activities that are mediated by the use of tools. The model involves a *subject*; a person or a group of people whose actions are directed towards the achievement of some object through the use of *tools*. The *object* of the activity is to be understood as the 'purpose' rather than an artefact and towards which the activity is directed. The object can be a material thing, or a less tangible thing like a plan or totally intangible like a common idea as long as it can be shared for manipulation and transformation by the participants of the activity. Activities are distinguished from each other according to their objects. In addition, the existence of an activity is motivated by transforming objects to *outcomes*. The relation between the subject and the object of an activity is mediated by a *tool*. The 'tool' is, as discussed above, anything used in the transformation process, including physical tools (e.g. technology) and conceptual tools (e.g. language).

Figure 3-1 The activity theory tool mediation triangle (Kuutti, 1996)



The concept of tool mediation is central to this thesis because it enables studying students' learning activities that are mediated by the use of tools (old and new) as part of their routine study activities. This also aids studying mobile learning through empirical studies that investigate real-world examples of students' activities. The term mediation is used here to refer to how tools are used to accomplish activities and to understand the relationship between tools and activities; specifically, whether activities are enabled or constricted by the tools.

3.4.3 The activity system

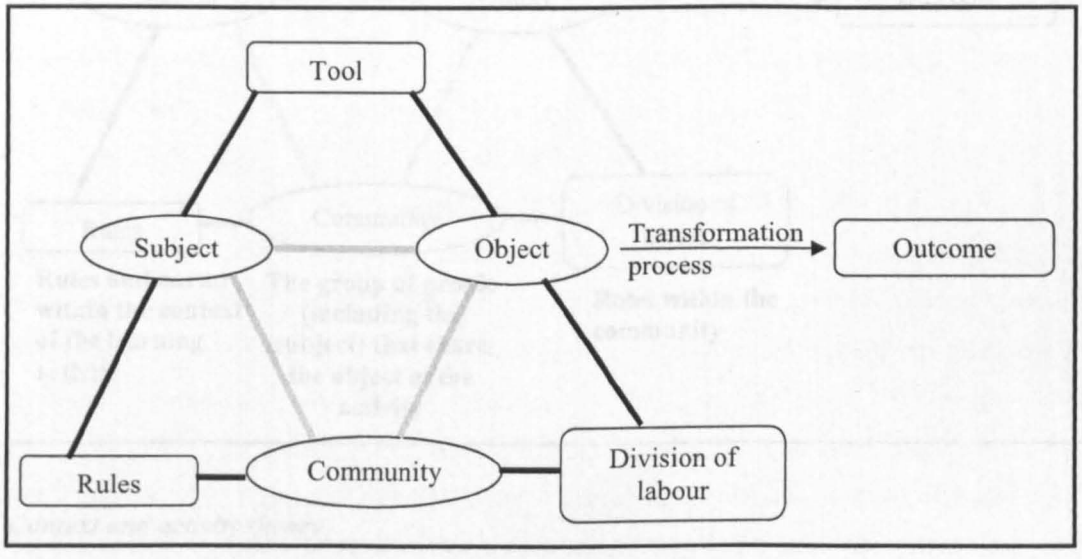
Engeström (1987) expanded Vygotsky's mediational model, shown in Figure 3-1, and developed the *Activity system* (shown in Figure 3-2) which includes the social context of an activity, represented in the *community*, *rules* and *division of labour* components. The *rules* cover both explicit and implicit norms, conventions and social relations within a community. The *division of labour* refers to the explicit and implicit organization of a community as related to the transformation process of the object into the outcome (Kuutti, 1996). The *community* includes the people that are involved in an activity and who share the same object. Engeström (1993) argues that members of the community do not necessarily share the same single objective as the central actor. Rather, they share the same 'general objective'; as different members of the community are related towards unique, but related, objectives that contribute towards the general objective. Kaptelinin (1996, p. 58) referred to this as *polymotivation*: 'it is not necessary that all component subjects share the motive of the system they are incorporated into, but the goals of the subjects should permit polymotivation, that is, should satisfy motives of both the component subject and the system'. For example, a student that is member of a group of students who are engaged in solving an exercise during a lecture is part of a community that consists of the other fellow students in the group, who share the same general objective, solving the exercise. At the same time, other community members may have other objectives such as using their laptops to engage in other activities like using instant messaging software or using search engines to find more resources on the web to help solving the exercise. This shows that activities are not stand alone, but they are part of 'an

interconnected web of activities' (Kuutti, 1991, p. 534). They can also reflect the collaborative and collective nature of human activities.

The discussion of the Vygotsky's mediational model above and the activity system components showed that there is some ambiguity in the distinction between the subject and the community components. The subject was defined as a person or a group of people engaged in an activity, and the community was defined as those who share the same object (Kuutti, 1996). Engeström (1993) argues that the definition of the subject as an individual or a group depends on the research object.

Engeström's activity system includes three mutual relationships between the subject, object and community components. The relationship between subject and object is mediated by 'tools', the relationship between subject and community is mediated by 'rules' and the relationship between object and community is mediated by the 'division of labour'.

Figure 3-2 Basic structure of an activity (Kuutti, 1996)

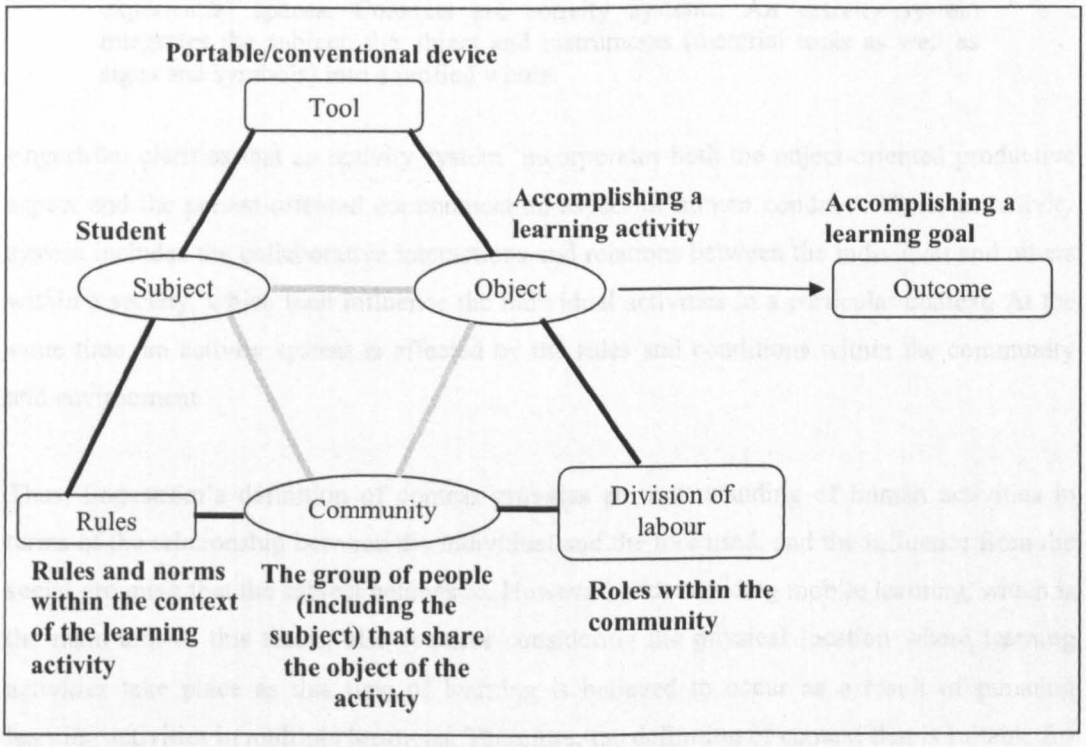


Engeström (1993) argues that the development of the activities is caused by the contradictions that occur between the objectives of these activities. The different types of contradictions are discussed in the following subsection.

As Kuutti (1996) argues, the basic unit of analysis in activity theory is the 'activity' which has also been the units for analysis in many psychological theories. Thus, the unit of analysis in this thesis is also the learning activity that a student accomplishes in multiple contexts. Figure 3-3 shows a general level of the definitions of the activity system components and how each

was used in this thesis. The figure also shows how the cases in this thesis were interpreted using activity theory. The *subject* of the activities is considered the student who is using a tool to mediate learning activities. A *tool* is any device, old or new, that a subject uses to mediate his/her learning activities. Activities are directed towards an *object* which is an objective that the subject aims to accomplish within the *context* of the learning activity. The *community* in this activity system includes the group of people who share the object of the activity. The *rules* are considered to be the norms that govern the learners' community. And the *division of labour* represents the organisation of the students' community that shares the same objective.

Figure 3-3 Activity theory interpretation for this study



Context and activity theory

Another basic principle of activity theory is the concept of *context*. Cole and Engeström (1991) argue that in order to understand human activities it is crucial to understand how artefacts (such as tools and symbol systems) mediate the activity within the cultural context in which the activity is situated. Nardi (1996) also argues that in activity theory a minimal meaningful context for individual actions is required for basic analysis. She views context in activity theory as the activity system. She argues that

> Activity theory ... proposes a very specific notion of context: the activity itself is the context. What takes place in an activity system composed of object, actions, and operation, is the context. Context is constituted through the enactment of an activity involving people and artifacts. Context is not an outer container or shell inside of which people behave in certain ways.

> People consciously and deliberately generate contexts (activities) in part through their own objects; hence context is not just "out there" (Nardi, 1996, p. 76).

She goes on to state that context is 'both internal to people-involving specific objects and goals-and, at the same time, external to people, involving artifacts, other people, specific settings. The crucial point is that in activity theory, external and internal are fused, unified' (Nardi, 1996, p. 76).

Engeström (1993, p. 67) also sees context as the activity system. He argues that:

> For activity theory, contexts are neither containers nor situationally created experiential spaces. Contexts are activity systems. An activity system integrates the subject, the object and instruments (material tools as well as signs and symbols) into a unified whole.

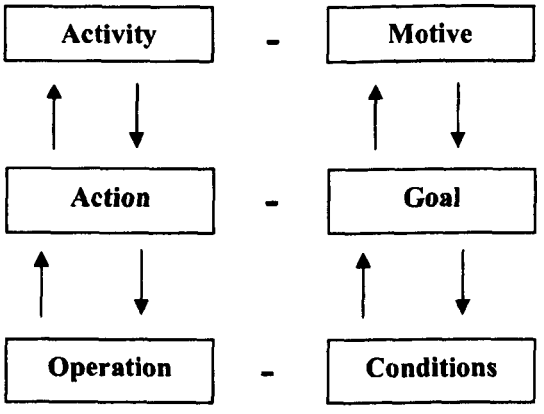
Engeström clarifies that an activity system 'incorporates both the object-oriented productive aspect and the person-oriented communication aspect of human conduct'. Thus, an activity system includes the collaborative interactions and relations between the individual and others within a society, which then influence the individual activities in a particular context. At the same time, an activity system is affected by the rules and conditions within the community and environment.

Thus, Engeström's definition of context provides an understanding of human activities in terms of the relationship between the individual and the tool used, and the influence from the social grouping that the subject belongs to. However, understanding mobile learning, which is the main aim of this thesis, also requires considering the physical location where learning activities take place as this type of learning is believed to occur as a result of pursuing learning activities in multiple locations. Therefore, the definition of context that is suitable for investigating the main aim of this thesis (mobile learning) is derived from the discussion of context in Section 3.3. It has been argued that context can be considered either as the physical setting of the space where learning activities take place or the social setting (represented as the rules and roles that govern the community engaged in the object of the activity) of the learning activities as in Engeström's definition above. Thus, the investigation of context and learning activities in this thesis starts by examining these two perceptions to find which of these definitions is sufficient for investigating mobile learning or whether both are essential. The definition of context is revised in Section 5.5.2. Initially, however, context refers to the 'space' of learning activities, which is the interpretation used by many researchers in the field (e.g. Sharples, 2003; Bull and Reid, 2004; Byrne et al., 2004; Chan et al., 2004).

The three levels of activity

Leont'ev (1978) developed the notion of hierarchical levels of human activity by distinguishing between 'collective activity' and 'individual action'. He views human *activity* as a complete system that consists of *actions* and *operations*. Thus, the object of an activity can be transformed to outcomes through multiple steps and phases that consist of actions or chains of actions, which in turn consist of operations. Figure 3-4 shows Leont've's model of human activity which can be useful to understand the nature of activities.

Figure 3-4 Hierarchical levels of an activity (Kuutti, 1996, p. 30)



At the highest level of the hierarchy are the *activities*, individual and cooperative action and chains and networks for such actions, related to each other by the same object and distinguished by their ***motives***. The second level includes *actions* which have an immediate and defined ***goal***. Members in the activity system undertake actions in order to achieve a specific goal that contributes to the overall motive of the activity. Actions are distinguished by their goals. Both activities and actions are achieved through the use of available tools which represent the ***conditions*** of the activity and determine the *operations*, or routine processes, that are used. Actions are usually consciously planned using a model before actually being performed in the real world (Kuutti, 1996). Kuutti argues that when the corresponding model is good enough and the action has been practised long enough, actions will be collapsed into operations where people are so fluent that they do not always think about what they are doing. Thus, practices are understood in this thesis as routine patterns of activities repeated over time in a social context.

3.4.4 History and development

The notion of historical-development in activity theory presents the view that activities have their own history as they and their elements are under continuous, non-linear, uneven change and development (Kuutti, 1996). The historical development of human activities takes place

as a result of social and cultural changes that occur in the community where these activities are performed. Remains of previous activities are usually embedded in them as they develop. Thus, understanding learning activities requires historical analysis of these activities, from a social and cultural point of view, which can be useful to provide understanding of the current situation of the learning activities. In addition, it requires studying activities in the context where these are situated to get an insight into why an activity is carried out in a particular way and why certain types of devices are used instead of others to accomplish an activity. The following sub-section discusses the concept of contradictions in activity theory through which activities evolve.

Contradictions

Another central idea of activity theory is the notion that activities are in constant development and transformation. The development of an activity is motivated by the introduction and resolution of contradictions (problems, clashes, breakdowns) that occur within and between activities. Kuutti argues that:

> Because activities are not isolated units but are more like nodes in crossing hierarchies and networks, they are influenced by other activities and other changes in their environment. External influences change some elements of activities, causing imbalances between them. Activity theory uses the term *contradiction* to indicate a misfit within elements, between them, between different activities, or between different developmental phases of a single activity. (Kuutti, 1996, p. 34)

Engeström (1987) argues that there are four levels of contradictions within the activity system, illustrated in Table 3-1. A *primary contradiction* resides on each component of the activity system as a dual tension between the use value and the exchange value. Engeström illustrates this type of contradictions through an example of medical work activity: doctors experience continuous tension between their role as gatekeepers and cost-efficient producers where they must see as many patients as possible to maintain a cost-efficient service on the one hand, whilst on the other, they need to spend as much time as possible with patients to accurately diagnose them and prescribe treatment.

Secondary contradictions appear between the components that reside at the corners of the triangle of an activity system. This type of contradictions appear when a strong novel factor is 'injected' in one of the components of the activity which then drives development and change in the system (Engeström, 1993). For example, in a study conducted by Waycott (2004) to study the utilisation of portable devices (specifically PDAs) by Open University students for reading course materials, she argues that PDAs' portability resolved a contradiction between the rules and the tools of the activity where the informal regulations of Open University study

suggest that students must make use of every little bit of spare time they can. However, the used tools, mainly A4 size folders and desktop computers, were not conducive to this rule. At the same time, the introduction of PDAs introduced some contradictions where these devices did not support some of the students' established reading strategies such as skim-reading, annotating text or drawing diagrammatic notes.

Tertiary Contradictions occur between the existing activity system and its *culturally more advanced form* (Engeström, 1987). This contradiction is caused by the object/motive of the new form of the activity which challenges the object/motive of the dominant activity. For example, when practitioners of a medical care system are asked to implement new procedures, they will be formally implemented but probably still rejected and subordinated by the old general form of the activity (Engeström, 1987).

Finally, *Quaternary Contradictions* appear between the central activity and its neighbour activities (Engeström, 1987). This type of contradiction appears between the activity systems in the process of implementing the outcome of the central activity. For example, in Waycott's (2004) study where she studied the integration of new technologies (PDA) in workplaces, contradictions occurred between the activity of integrating PDAs into workplace practices and the co-existing activity of providing departmental IT support because IT support activity had its own set of rules, division of labour, and objectives which were different from the rules, division of labour and objectives of the PDA activity.

Table 3-1 The four levels of contradictions in activity theory (adapted from Engeström, 1987)

Primary contradictions	*Within* each constituent component of the central activity.
Secondary contradictions	*Between the* constituents of the central activity.
Tertiary contradictions	*Between the* object/motive of the dominant form of the central activity and the object/motive of a culturally more advanced form of the central activity.
Quaternary contradictions	*Between* the central activity *and* its neighbour activities.

The concepts of historicity and development are used in this thesis to study mobile learning and provide an insight into learners' activities that take place in multiple contexts. The concepts were also used to study students' utilisation of portable devices in formal and informal learning settings. In addition, the concepts enabled studying how students' learning practices develop as a result of the introduction and resolution of contradictions. Moreover, the concept of contradictions was used to understand the relationship between context and students' activities which are developed as a result of resolving the contradictions that occur within and between the components of an activity system.

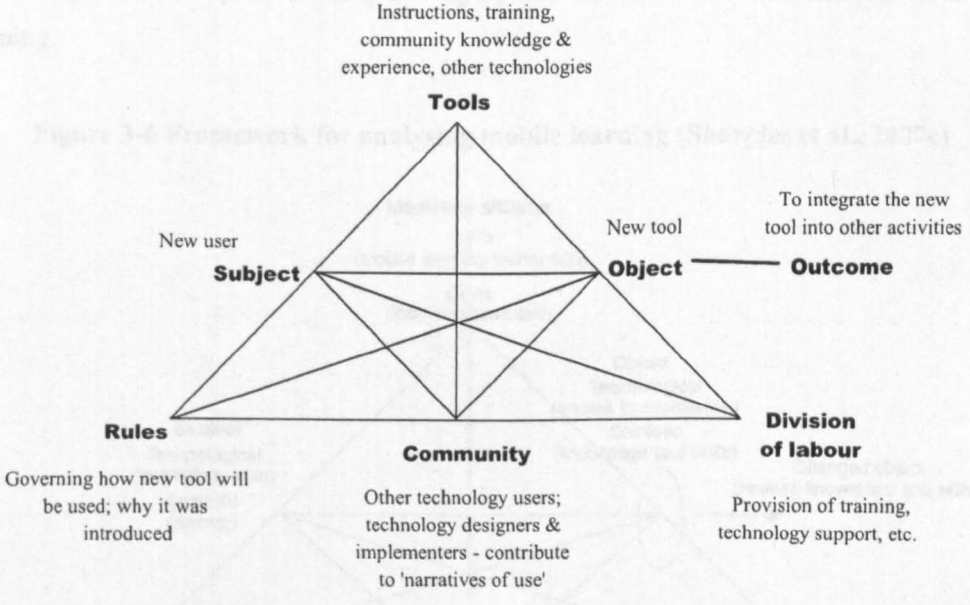
3.4.5 The application of activity theory to mobile learning

The discussion above provided an overview of activity theory and its main concepts that are relevant to this thesis. This subsection discusses two examples of current research in mobile learning that used activity theory as an analytical framework. Activity theory has been used as a framework for studying mobile learning because it provides a framework for studying activities that are mediated by the use of tools and accounts for the context where these activities are situated.

Waycott's Application of Activity Theory to mobile learning

Waycott (2004) used activity theory to study how PDAs mediate learning and workplace activities and determine how sociocultural factors influence tool appropriation. She developed the Activity System Tool Appropriation Model (ASTAM), shown in Figure 3-5, which is based on Engeström's (1987) expansion of activity theory. The model represents tool appropriation as an activity system. Tool appropriation in her study is defined as the integration of a new tool into the user's activities where the new tool is the PDA which is both the object of this activity and a mediating tool in other activities.

Figure 3-5 Tool appropriation as an activity system: The Activity System Tool Appropriation Model (ASTAM) (Waycott, 2004)

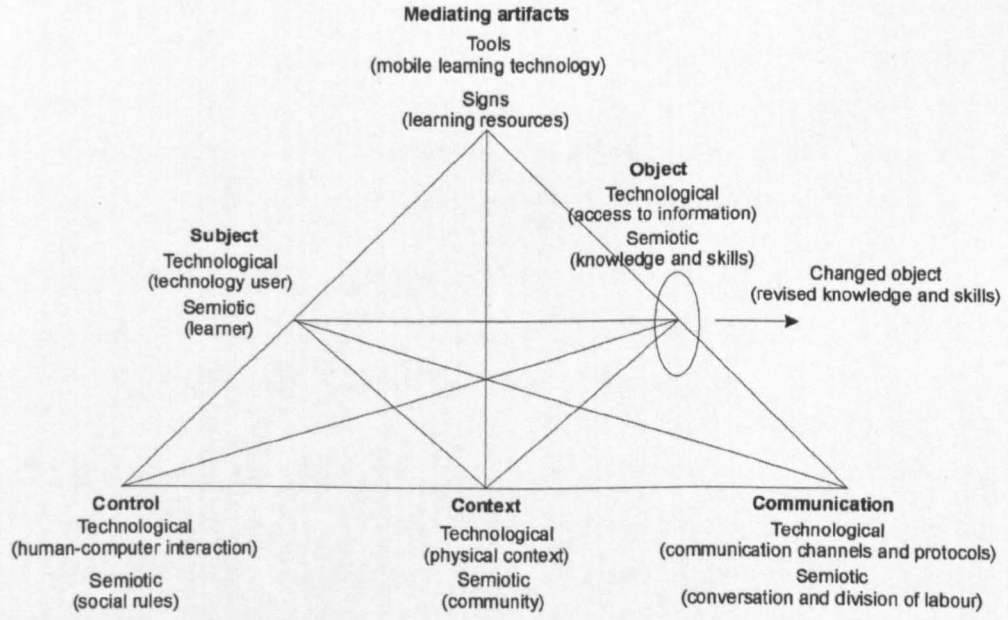


Waycott used ASTAM to analyse the activity of tool appropriation. She categorised, interpreted and analysed students' interview data by drawing activity system triangles to represent the main work activities that each interviewee described. This also helped to reveal the contradictions in the activity system in relation to the use of portable technologies.

Sharples et al.'s Application of Activity Theory to mobile learning

Sharples et al. (2007c) attempted to describe the activity system of mobile learning through the use of Engeström's (1987) expansion of activity theory by describing the relationship between people and technology. They used activity theory in combination with the conversational framework (Laurillard, 2002) to indicate the importance of conversation and context in understanding mobile learning. Based on that, they developed a two-layered version of Engeström's expansion of the activity system triangle, shown in Figure 3-6. They argue that it is helpful to separate two layers of tool-mediated activities in order to analyse the activity of mobile learning. First, the semiotic layer describes learning as a semiotic system where learners' object-oriented actions are mediated by cultural tools and signs. The learner internalises public language that is instantiated in writing and conversation which then provides the resource for the control and development of activity (Vygotsky, 1978). Second, the technological layer represents learning as an engagement with technology where tools, such as computers and mobile phones, are used as interactive agents in the process of coming to know. This layer creates a human-technology system to mediate agreements between learners (e.g. spreadsheets and concept maps), and aid recall and reflection (e.g. online discussion lists). The researchers suggest that these two layers should not be separated from each other, nor be superimposed; they should be put in a continual dynamic where they can be moved together and apart, creating an engine that drives forward the analysis of mobile learning.

Figure 3-6 Framework for analysing mobile learning (Sharples et al., 2007c)



3.5 Conclusion

The chapter described the theoretical background of this thesis. First, the chapter discussed a theory of mobile learning by Sharples et al. (2007c) that is developed as an attempt to theorise and study learning in the mobile age. Second, the concept of context was explored to show its complexity and the relationship between context and learning activities. The chapter also discussed the central concepts of activity theory that are relevant to this research. The next chapter discusses the methods and methodology used to conduct the studies that investigate the research questions in this thesis. The chapter also discusses how the analytical frameworks are used to analyse the research data.

Chapter 4

Methodology

This chapter introduces the methodology used to conduct the studies in this research. It begins with a discussion of the current methodologies used for studying the utilisation of portable technologies for learning, illustrating their features and shortcomings. This is followed by a discussion of some of the methodological issues raised as a result of selecting activity theory as an analytical framework for this research. Then, the research questions are discussed in greater detail, as well as the methods used to investigate each of these. This is followed by a proposal for the design of a pilot study that investigates the research questions and which also overcomes the shortcomings of the methodologies used in previous research.

4.1 Related methodological issues

As discussed in the previous chapter, the main aim of this thesis is to develop a conceptualisation of 'mobile learning' through empirical studies that investigate students' utilisation of portable devices in different formal and informal contexts. However, research in mobile learning faces challenges in terms of data collection as a result of the change in the context of learning activities as learners carry out learning activities in different physical locations. This requires using research methods that enable collecting data that reflects students' learning activities in these contexts. Taylor (2007) argues that research in mobile learning faces a number of challenges because of the mobility of learning environments and the unavailability of a comprehensive framework for such a novel area of research. She argued that evaluation in the mobile age requires activity analysis (from whatever theoretical perspective) as well as context. The theoretical framework used in this thesis, namely activity theory, enables analysing learners' activities in the context where these are situated.

4.1.1 A review of current methodologies

This section reviews existing approaches used to study students' utilisation of portable devices and identifies the strengths and weaknesses of these approaches.

Methodologies for studying students' use of portables

Many researchers in the field are interested in studying mobile learning empirically through exploring the possibilities and constraints introduced by mobile technologies for teaching and learning in different settings (e.g. Hennessy, 2000; Waycott, 2002; Corlett et al., 2005). The

literature review, discussed in the previous chapter, showed that most of the current studies were conducted similarly. In these studies, students were supplied with portable technologies at the time of the study and were asked to use them to accomplish their learning activities. These activities would normally be accomplished using other types of devices. A variation on this approach is where learners are asked to undertake specified tasks assigned by researchers. Then, at the end of the study, students' perceptions were gathered through self-report techniques such as interviews and questionnaires. For example, Waycott (2002), who also used activity theory as an analytical framework, conducted a study that investigated the use of PDAs for reading course materials. The researcher provided students enrolled in a Masters course with PDAs and asked them to use the devices to read course materials. Before the study, students usually used conventional devices such as handouts to read course materials. At the end of the study, which lasted 3 months, the researcher gathered students' perceptions through questionnaires and telephone interviews.

The methodologies used to conduct the studies have a number of limitations. First, the studies' findings reflect on students' portable usage over a relatively short period of time (e.g. Waycott's study took approximately 3 months from the day students were supplied with PDAs to the day they were interviewed). Thus, the research findings may not reflect on students' established use of the technology to accomplish their routine study practices. This is also affected by the complexity of the used device as some devices require more time for users to become familiar with than others. Second, the studies involved students enrolled in the same course, which may lead to students' technology usage to be similar. This may also hamper uncovering different technology usage patterns and the benefits and limitations that students find when using portables for different purposes and in different contexts. In addition, students' excitement and enthusiasm about the new technology may influence their responses and thus bias the research towards an overly positive evaluation (Waycott, 2004). Third, the studies relied on students' self-reports as the main source of data. These responses could not be trusted as the only source of data because differences can be found between what learners say they have done, or will do, and what actually they did, or will do. Self-reports also lack accuracy and cannot provide detailed description of students' activities that take place in different contexts (Robson, 2002).

Other researchers used multiple research methods to get in-depth data about the utilisation of portable devices in different settings. For example, Sharples et al. (2007b) conducted a study to evaluate the MyArtSpace project which used mobile phones and web-based services to support learning between schools and museums. In the study, prior to the museum visit, students were introduced to the topic of the visit and provided with worksheets that included

questions that students were to investigate in the museum. During the museum visit, students were supplied with mobile phones to help them explore the museum in groups and collect items relevant to the topic in the worksheets, such as pictures, audio commentaries and notes. The researchers collected data through combining self report methods, questionnaires and interviews, with observations of students during their engagement with mobile phones in the museum and using computers to develop a gallery about the museum visit at school. However, although these methods helped with investigating learners' activities in the museum and in pre- and post- visit sessions, they were not designed to support the broader study of learners' activities outside the school or museum that might also have been aimed at achieving these same objectives.

Similarly, Papadimitriou et al. (2007) conducted a study to investigate a collaborative learning activity created for a historical museum. The main aim of the study was to introduce students to a new form of interaction with the exhibits in the museum, focusing on the tools used and the interaction between participants. In the study, groups of 4-5 students were provided with PDAs and were asked to use them during a museum visit to collect, manipulate, and combine data that is extracted from the exhibits in order to identify the exhibit that is described by the learning scenario. The researchers collected data through recording the dialogue among the participants, video recording the participants in one museum room, and screen capturing of the PDA. The researchers analysed the data using activity theory through the Collaborative Analysis Tool (ColAT). Avouris et al. (2004), as cited by the researchers, argue that ColAT enables looking at the low-level operations and goal-oriented actions of students' activities. The tool also supports multilevel description and interpretation of collaborative activities through synchronising the multiple sources of data collected through multiple methods. The research methods and the tool used to conduct the study helped with organising the data and providing detailed description of students' learning activities. However, this study was focused on learning activities that took place in the museum room and did not consider cross-contextual issues such as students' learning activities that took place in different museum rooms or outside the museum.

Methodologies for studying university laptop programs

Other studies looked at the laptop programs implemented by universities (e.g. Zelin and Baird, 2002; Demb et al., 2004; McVay et al., 2005; Weaver and Nilson, 2005) which either provided students and instructors with portables or required students to buy or lease their own. These studies followed a different research approach. They investigated students' usage of portable devices both inside and outside the classroom and the effect of these technologies

on students' learning practices. However, the studies were again based on students' and/or instructors' self-reports through interviews and questionnaires.

Techniques used in related fields of study

The review of the literature showed that most of the studies that investigate students' utilisation of portable devices were based on students' self-reports which are collected through interviews, questionnaires or students' reports that provide information about their portable technology usage. As discussed earlier, using self-report techniques alone cannot be trusted as students' responses cannot be assessed for credibility against any other account or source of data (Robson, 2002). Other techniques can be used to triangulate and add a valuable secondary perspective to the interpretation of the data. For example, in the field of studying the effect of computers on students, Crook and Barrowcliff (2001) studied how campus-resident students make use of a network and the versatile infrastructure of desktop computers. Although this study is not from the field of mobile learning, arguably, it is relevant because it is concerned with students' educational practices in different contexts. The researchers selected a random sample of campus-resident students and used two methods to collect data: interviews and students' computer log files. Students agreed to install system monitoring software on their computers to track their activities on their computer. The software continuously identified and time stamped system activities and changes in input focus between application windows. The resulting information was appended to a database file on the students' hard disk. These files were then collated for analysis. The researchers also interviewed the participants before conducting the study and used the gathered data from the system logs to adjust and validate the data gathered through interviews. For example, when the researchers wanted to measure students' work-play ratio, they compared the data given by students in the interviews and an estimated ratio based on the categorisation (based on their relevance to the curriculum) of visited web sites from the students' computers log files. Only a slight difference was found between the two ratios, which meant that in this case the log files were validating students' self-reports.

4.1.2 Methodological implications of activity theory

As presented in Chapter 3, this thesis is informed by activity theory because it (a) enables the understanding of how students mediate portable devices to accomplish their routine learning activities and (b) considers the context of learning activities. However, activity theory does not provide any clear methodology to guide how activities are to be recognized, described, and analysed (Bodker, 1996). Tolman (1999) argues that qualitative research methods are most appropriate for an activity theory approach because they provide rich descriptions of the activity systems under investigation. They also do not identify predictive variables which

statistically link a social phenomenon with a discrete cause because this is inconsistent with activity theory's holistic principles. Tolman also argues that predictive variables specify that there is a relationship between the social phenomenon and the identified variable, but do not help in describing the relationships or the processes in that phenomenon which also requires a more holistic approach. Thus, research that is informed by activity theory involves different qualitative strategies such as ethnographic studies (e.g. Macaulay et al., 2000), observations (e.g. Bodker, 1996), and interviews (e.g. Waycott, 2002).

Based on the discussion above, the methods used to conduct the studies in this thesis have been chosen to be consistent with its purpose and theoretical foundation. This involves qualitative and ethnographic methods such as observations of students in their natural setting (formal and informal), interviews and log files collected from students' portables. These methods, especially observations, are a good choice for providing rich descriptions of students' learning activities that take place in formal and informal settings. The methods also facilitate capturing the actions and operations of students' activities, thus more aggregated analysis of the activities. Although operations are usually captured through observations, Nardi (1996) argues that interviews should be considered as a source for operations as they provide a way for the subjects to talk about the operations they undertake, which may provide a different perspective on the phenomenon.

As activity theory does not offer ready-made techniques and procedures for research; Engeström (1993) discussed three guidelines that are crucial for operationalising the concepts of activity theory, discussed in Section 3.4, and which can be applied according to the specifics and nature of objective of the activity under investigation:

1. The first principle is *considering the entire activity system as the unit of analysis.* This principle requires understanding where to draw the boundary and how to identify the collective activity system from the environment. It also requires identifying the components and attributes of the collective activity system which include understanding the context in which the activity is situated.
2. The second principle is *historicity as the basis of classification.* The historical development of the activity needs to be examined in the context in which the activity is usually carried out. This was done by studying students' activities that took place in different contexts over the period of the study.
3. The third principle is *contradictions as the source of change and development.* It is crucial to identify the contradictions within and between the components of the activity system when analysing the gathered data as this helps with developing an understanding of the activity being studied.

4.1.3 Summary

The limitations of the reviewed studies and the methodological implications of activity theory, discussed above, suggested several criteria for the design of this research:

- Studying mobile learning requires gathering detailed description of learners' activities that take place in multiple contexts (formal and informal). In addition, it requires using research methods that enable studying the longitudinal pattern of technology usage in and across contexts and gather information about the context of learning activities. This was done by collecting data through observations of students in different contexts and log files collected from students' portables using monitoring software.

- Second, this will involve studying students' self reports regarding their utilisation and perceptions of using portables, which they already use, to accomplish their routine learning activities through questionnaires and interviews.

- Third, it will involve using data collected through observations of students and log files to triangulate students' self-reports to provide evidence on how accurate students' perceptions are. This should improve the accuracy of the collected data and add a valuable additional perspective to the interpretation of the data collected through self report methods. Robson (2002) argues that using multiple methods to collect data permits 'triangulation' that helps in finding out where something is by getting a 'fix' on it from two or more places.

- The study should involve students from different courses (e.g. science, engineering and social sciences), which some of the reviewed studies lacked as all students were enrolled in the same course. This will help with exploring the similarities and differences across context of use in these courses.

- The study should investigate students' established use of a technology which the studies in the literature lacked as they were mainly focused on studying students' adaptation of new technologies for learning. In the studies presented in this thesis, the university students were selected from the 2nd or 3rd years undergraduate programs as they are immersed in using the technology for their study practices. (However, as will be seen, differences still could be found between students; year of study alone might not determine how immersed students are in using the technology.)

- Students' learning activities were studied in a holistic manner. This was achieved by studying students' activities in different contexts (formal and informal). This reflected on the first guideline of operationalising activity theory that is proposed by Engeström (1993) which argues that the basic unit of analysis is the activity system. The activity system consists of the student engaged in an activity through the use of portable devices (old or new) within a community that is governed by a set of rules and division of labour. Activities have been studied in relation to the context where they are carried out. At this point context is understood as the physical and/or social features of the learning activity, illustrated in Section 3.4. The notion of context will be reviewed in Section 5.5.2 as a consequence to the empirical work conducted in the pilot study.

- The historical development of students' learning activities has been studied in the context where these activities were situated (Engeström's second guideline). This was achieved by means of studying the development and continuity of students' learning practices in and across different contexts (formal and informal). (However, considering this guideline was not practical until the third study, discussed in Chapter 7. It helped to account for the continuity and historicity of students' learning practices that take place in different contexts over time to study mobile learning.)

- Learning practices have been analysed in terms of the impact of contradictions that occur within and between the components of the activity system (Engeström's third guideline). This helped in studying students' learning practices and how these develop as a result of the introduction and resolution of contradictions in the activity systems.

4.2 Examining the research questions

As discussed earlier, answering the research question requires using multiple research methods: observations, log files, questionnaires and interviews. This section discusses how each of the research questions can be answered through these methods.

Question 1:

What is mobile learning?

As discussed in Section 3.1, the basis for understanding mobile learning in this thesis is provided by Sharples et al.'s (2007c) mobile learning properties. The properties, as these researchers argue, can help with distinguishing mobile learning from other forms of learning.

Answering this research question requires, first, collecting data that reflects on students' learning activities through observations of students in formal and informal settings and collecting log files from students' portable devices through system monitoring software. Log files are specifically helpful with providing data about students' utilisation of portable devices in places the researcher cannot observe. Second, the properties can be used when analysing the cases. (As will be seen, using the properties to analyse the research data raised questions that helped with reformulating the mobile learning properties proposed by Sharples et al.'s (2007c) and thus presenting the conceptualisation of mobile learning introduced in this thesis. This shows that the theoretical understanding of mobile learning here was redeveloped based on the conducted empirical work.)

Question 2:

How do students in HE utilise portable technologies in formal and informal settings?

To gather data that answers this question, students were asked to complete a questionnaire (Appendix C) that investigates their utilisation and perceptions of using portables devices for learning in formal and informal settings. The questionnaire was used to provide a general idea about students' utilisation of portables in different settings. Students' self reports were then triangulated with data collected through observing them in these settings and/or collecting data form their portables through log files. The log files were especially helpful with providing data about students' utilisation of portables in informal settings as students could not be observed all the time. Students' portables usage in informal settings was also studied through observations in some public places such as the university library. The researcher was opportunistic, observing students in these places before getting their informed consent. This was necessary, in that relevant learning practices could not be identified until they happen, but also ensured observing students' actual use of the technology. The collected data was only used when students granted their agreement to use the data which was requested after the observation. This was done by approaching the students after observations, providing them with information about the study and asking them to sign the consent and authorisation form. If students did not grant their agreement for the data to be used in the study, the observation notes were handed to students to dispose. Using observations and log files to collect data provided in depth descriptions of students' learning activities in formal and informal settings. It also helped with collecting data about the context of these activities. Students were also interviewed in order to clarify some of the issues that were observed or found in their log files.

Focus Question 1:

How does the use of portable technologies differ when they are supplied as part of a study, rather than when they are used by students as part of their routine study practices?

As discussed in the literature review, most of the reviewed studies were conducted by providing students with portable technologies at the time of the study. These studies did not reflect on students' established use of the technology to accomplish their routine learning practices. One of the aims of this research is to study students' established use of portable technologies to accomplish their routine learning practices. It can be argued that the time spent using any technology has an impact on the way this technology is used and the benefits/limitations offered by the technology. For example, students that use portables routinely may be more dependent on the technology than those who use the technology occasionally. Students may feel that they cannot complete their tasks if they did not have their portables with them. In addition, students may use portables to accomplish most of their learning activities, accomplish activities that the students with little experience of the technology may use conventional devices to accomplish and consider the devices as a substitute to their notebooks and other traditional learning tools. Thus, 2nd and 3rd year students were studied to represent students who are immersed in using a technology.

However, for financial reasons, the researcher was not able to supply students with portable technologies to study the effect of unfamiliar technology. Therefore, the comparison between portable usages when supplied as part of a study and when used as part of students' routine study practices was made by comparing the findings with the literature.

Focus Question 2:

What is the influence of portable technologies on HE students' educational practices?

Using any technology for teaching and learning includes both benefits and limitations. For example, students may find using portables improves their learning and time management as portables allow students to do their work whenever and wherever they are. Some students may find using portables enhances their motivations and attitudes to learning. Others may find them distracting in formal and informal settings as they can be used easily to engage in activities that divert education. Some may not notice any change to their time management and educational skills.

Students were asked to complete a questionnaire that includes questions about the benefits (usefulness) and limitations that students find when using portable technologies to accomplish their learning practices. Students were also interviewed to get more details about their practices and their portables' perceived benefits and limitations. The gathered data was

validated by log files as students' responses may not be accurate, correct and honest. The log files provided information about how often students use their portables in formal and informal settings and the applications they used. This gave an indication of the purpose of their usage and thus the benefits/limitations of such usage in certain contexts. For example, if students' log files show that students often use word editors outside the classroom, this might indicate that students often do their assignment while they are in the campus which provides evidence for conclusions about students' time management. The data can also be validated by observing students in different settings which gives ideas of the type of devices students use in different formal and informal settings, the purpose of using these and the reason for using a specific device.

Question 3:

What is the relationship between context and students' learning activities?

As discussed in Section 3.3, in order to understand humans' activities it is crucial to examine them within the context they are situated in. Context was understood in Section 3.4.3, initially, as the physical and/or social features of learning activities. Context may influence the activities that students engage in and their ability to achieve the desired tasks within that context. For example, the context that learning activities are situated in can influence the type of device students use to facilitate their learning. In this thesis, the relationship between context and students' learning activities has been studied through the questionnaires where students clarified the activities they pursue in different contexts and why. Observations and log files also provided in-depth data about students' activities in different contexts (formal and informal). This helped with identifying the purpose and patterns of portables utilisation in these contexts and clarified the impact of context on students' learning practices. Students were also interviewed to clarify any issues that were found in observations or the log files that seemed to indicate changes in students' practices in formal and informal settings which might be caused by the features of the context of learning activities.

Focus Question 3:

What is the impact of instructors' portables use on students' utilisation of portables?

Instructors' utilisation of portables influences students in many ways. Students may be influenced by the applications instructors use for class discussions, material preparation or research. Students may also be influenced by their instructors' expectations of students' technology utilisation as instructors unconsciously influence students' behaviour and their technology utilisation. In addition, students may consider their instructors to be experts and thus copy what their instructors do, seeking to emulate their expertise and knowledge. The impact that instructors have on their students' technology utilisations can be seen when

students use their portables for the same purposes as their instructors, or copy instructors' actions, like using instructors' document styles.

This question was investigated through the questionnaire which provided a general idea about the influence of instructors' technology utilisation on students' technology utilisation. Students were asked whether or not their technology utilisation is influenced by their instructors and why. The question was also investigated by observing students in formal and informal settings and then comparing both instructors' and students' use of portables to find what these had in common. This was supported by students' log files that identified the applications used inside and outside the classroom, allowing them to be compared with the applications used by the instructor inside the classroom. Interviewing students also clarified some of the issues that were found in log files and observations; this included explanation of the purpose of using some applications and if students' use was influenced by instructors' uses of these applications. For example, when instructors use their portables for simulations, some students may be encouraged to use them for the same purpose. Therefore, in this case students' use of portables for simulations might be influenced by the use of portables by instructors.

Moreover, classes where instructors used portables were compared with classes where instructors did not use portables. Students' usage from both classes were compared to identify differences which helped illuminate the influence of instructors' use of portables in classes. The impact was also examined by studying the portable-based activities and exercises given by instructors and whether these encouraged/discouraged students to use their portables to accomplish their tasks.

Focus Question 4:

What is the impact of context on students' communication?

Students communicate with others through multiple techniques such as face-to-face and using online chat rooms, bulletin boards and emails. This question was investigated through students' questionnaires which included questions about when, why, and the techniques that students use to communicate in formal and informal settings. The questionnaires also clarified the factors related to the physical/social features of the space where students are situated, which might influence students' communication. Students' patterns of communication were also studied through observations of students in formal and informal settings to gather data about the purpose of communication, the technique used and the type of device used. Observing students with and without portables in different settings helped with comparing the communication patterns of students. However, a challenge when analysing the cases in the

observational data is the possibly of misinterpreting what students are doing. Log files were useful to overcome this limitation as these assisted with identifying the purpose of students' discussions. Students were also interviewed to provide more clarification. Using observations and log files to study the relationship between context and students' communication patterns enabled looking at the similarities and differences in patterns in different contexts. For example, the influence of context on students' communication was reflected in the method students used to communicate in different settings, which may differ between contexts due to the change in properties of that context. This may also be affected by the purpose of communication which changes between contexts and thus influences the method and device used.

4.3 Research plan

After reviewing some of the methodologies that are currently used in the area of study and identifying some of their shortcomings, and exploring how the research questions of this thesis can be answered, this section proposes a study plan that attempts to overcome the discussed limitations and answers the research questions.

4.3.1 Population and sampling

Population

The population for the studies in this thesis comprises higher education students who use portable technologies (old or new) to accomplish their tasks in formal and/or informal settings.

Sample

Morrison (1993) argues that the quality of a research is not only determined by the appropriateness of methodologies and instruments applied, but with the suitability of the sampling strategy that has been adopted by the researcher.

The research sample was selected to involve:

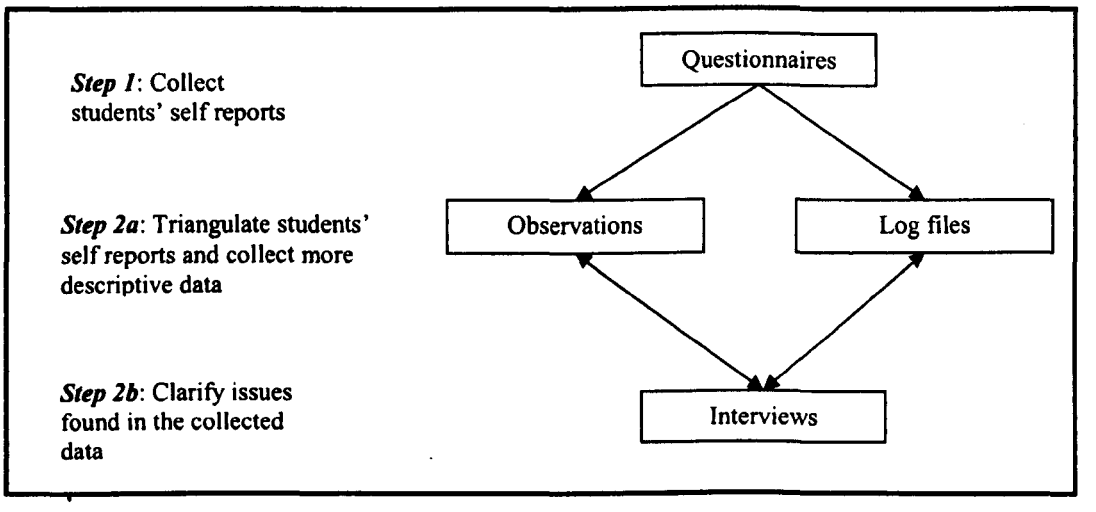
- Students from different undergraduate courses (e.g. Science, Engineering and Social Sciences) in two higher education institutions.
- Students from 2nd or 3rd year on the assumption that they are immersed in using the technology, to ensure studying students' established technology usage.

4.3.2 Study design

The study was conducted in higher education institutions where students use portable devices (old or new) to accomplish their learning activities in formal and/or informal settings. In the

beginning of the study, instructors from different courses were asked to provide the researcher with access to their classes (Appendix B). Students enrolled in these courses were asked to take part in the study and were provided with information about the study and how they could participate. Students were guaranteed their anonymity, privacy, confidentiality, and their right to withdraw from the study at any time and might not complete any part of the study. Those who agreed to participate were asked to sign and return the Consent and Authorisation form (Appendix A). They were also asked to complete a questionnaire that included questions regarding their perceptions and utilisation of using portables for learning practices. After that, students were observed while they were interacting with their portable devices to collect data about how they use their portables in formal and informal contexts and the relationship between context and learning activities. At the same time, students' utilisation of portables in formal and informal settings was logged using system monitoring software installed on students' laptops. During the study and at the end of it, students were interviewed to provide more description and clarification to some of the issues that were observed or found in students' log files. Figure 4-1 shows the sequence and purpose of data collection methods used in the studies in this thesis.

Figure 4-1 Study design



Here is an example that clarifies how the research methods were used to collect the research data: a student was approached and asked to participate in the study. The student was provided with information about the study and what his participation involved. When the student agreed to take part in the study, he was asked to sign a consent and authorisation form and complete the questionnaire. At the same time, the system monitoring software was installed in his laptop to help gather data about his utilisation of the device in different formal and informal settings. It is important to highlight that the main portable technology that the

students in the studies used to aid their learning activities were laptops. The student was then observed in multiple formal and informal settings to investigate his utilisation of portable devices in these settings. The data gathered through observations and log files helped with validating the collected data. The student was also interviewed to clarify some issues that were observed or found in log files. The data collected through interviews was also validated through observations and/or log files.

4.3.3 Research methods selection and data analysis

As discussed in the previous section, a number of methods were used in order to investigate the research questions. These are questionnaires, observations, log files and interviews. This section discusses how data have been collected and analysed using these methods. The section also discusses the methodological, ethical and logistical concerns and challenges of these methods.

Questionnaires

The primary purpose of the questionnaires was to gather the responses of students about their utilisation of portable devices to accomplish their learning practices in formal and informal contexts. In addition, the questionnaires helped with gathering demographic data about the participants such as gender, what type of portables they use and how often they use them in formal and informal settings. Moreover, the questionnaires enabled gathering data about students' portables utilisation and their perceptions, behaviours, and attitudes towards using the technology for their learning practices. Students' responses have aided clarifying and answering the research questions. The questionnaire also aimed to guide the research, especially observations and log files, as they helped with pinpointing some of the issues that required more investigation. Some of the questionnaire items were adapted from a similar study by Waycott (2004).

A semi-structured questionnaire was designed to collect students' self-reports; this type of questionnaire does not presuppose the nature of the responses. The questionnaire included closed questions such as multiple choice questions as well as open-ended questions to give students some space to express their thoughts (Cohen et al., 2000).

Concerns and challenges

One of the issues of concern when designing the questionnaire in this thesis was ensuring the reliability and validity of students' self reports. The reliability of students' responses is about the consistency of these responses. This means that if replicating the questionnaire, another researcher would get the same results if it was carried out at the same time and with the same

group of respondents. To improve the reliability of students' responses in the studies conducted in this thesis, the design of the questionnaire considered limiting the questions that are affected by students' characteristics such as memory, knowledge and experience. In addition, students were ensured anonymity as well as privacy for their responses as this encourages greater honesty because students will not be anxious that they will be identified (Cohen et al., 2000).

The validity of data, which is about students' responses being accurate, correct and honest, is also affected by asking leading/ambiguous questions or questions being misunderstood. In addition, the validity of the collected data is affected by students not reporting their beliefs and attitudes accurately. Therefore, when designing the questionnaire in this thesis, great care was taken to avoid asking questions that lead to particular answers, sentences were carefully structured using simple language and questions were kept clear and short.

Using questionnaires to collect data raised some ethical issues such as students' confidentiality, anonymity, and non-traceability. Students were guaranteed that the collected data and their identities will be confidential and that the research results will not affect them negatively. In addition, students were encouraged to complete the questionnaire, but, at the same time, they were given the right to withdraw at any time or not to complete any part of the questionnaire.

Data Analysis

The questionnaire responses were a mixture of both structured and unstructured data because of using a semi-structured questionnaire which includes both closed and open-ended questions. The closed questionnaire items asked for closed responses and these were quantified. Codes have been allocated to each of the closed responses which helped in organising, quantifying and analysing the collected data. The responses were then entered into an Excel spreadsheet to represent the data as diagrams that show the number of students and the percentages belonging to each of the categories for the variable in question. However, the nature of the study, which focuses on exploring learners' learning practices, primarily requires interpretative, qualitative analysis of the collected data. The study was thus designed so that no statistical analysis was undertaken as it was considered unnecessary and inappropriate.

The open-ended questions included in the questionnaire were designed to generate more in-depth data about some of the research questions. Students' responses were analysed by coding them and combining the detailed information contained in the responses into a limited number of categories which are similar in content. These categories were used in describing and

illustrating students' responses. Students' responses also provided information that helped in presenting case descriptions.

Observations

Observations were the main method used to collect data in this research because they offer the opportunity to gather data about students' learning activities while they occur (live). They also help with looking at things that might otherwise be unconsciously missed, discovering things that people might not freely talk about in a questionnaire or an interview, moving beyond perception-based data and accessing personal knowledge. Observations also help to collect information about the physical setting of the environment and the social setting within that like how students are organised and their characteristics, interactional arrangements that take place between students such as verbal and non verbal interactions, and program structure that clarify the pedagogic styles and the curricula (Cohen et al., 2000).

Observations were used to collect descriptive data about students' learning practices in different contexts and triangulate students' self-reports gathered through questionnaires and interviews, as differences can be found between what students say they have done, or will do, and what actually they did, or will do (Robson, 2002). The observations concentrated on students and their usage of portables such as the applications used, when, where and why they were used and the relation to the features of the context where these activities take place. The observational data was recorded by taking notes or using a table that includes all the above fields (Appendix D). In addition, lectures can be video recorded which provides a baseline for referring back to unclear points that may arise in the observational notes. This requires getting students' and instructors' authorisation and avoiding video recording those who would not wish to be video recorded by asking them not to sit in front of the video camera. (However, as will be discussed in Section 6.1.1, the video recording of students was not practical in this thesis because of restrictions placed by the universities on the studies in their premises as well as the participants.)

All observations were conducted by the researcher. In formal settings, the researcher usually sat at the rear of the class, observed students and took notes about students' activities using their devices (old and new) and their interactions with others. The researcher mainly focused on the participants, but at the same time observed other students who might be engaged in interesting activities. The non-participating were approached after the observations to ask for their permission to use the data for the research. The data was only used when students agreed, in some cases when students did not agree for the data to be used by the researcher; the notes will be handed to the students to dispose. The researcher also observed students in

informal settings. The researcher usually observed students in the class and then followed them when they left to other locations in the university such as the library and canteen. Below is an example of observational notes:

- The student gets in the class, switches on his laptop, and opens the lecture slides.
- The instructor comes in the class and asks students to open the lecture slides.
- The instructor starts discussing the slides.
- The student follows the instructor's illustration and writes notes in the notes area of the PowerPoint slides.
- The student is browsing the web looking for the meaning of a word that appears in the slides.
- He also checks his email.
- The instructor finishes illustrating the topic.
- The student leaves the class and goes to the library.
- He chats with a group of students and opens the previous lecture slides.
- The group are discussing the slides and at the same time using other resources to understand the material like specimens, books and the web.
- The student is writing down notes in the lecture slides displayed on his laptop.

Semi-structured observations were most appropriate for this thesis as they help the researcher to have an agenda of the issues to be observed and at the same time gather data that illuminate these issues in a far less pre-determined manner. This was because it is impossible to sample students' unplanned and unscheduled learning in advance; relevant data had to be identified by relating observations to the theoretical concerns that were being explored as they happened. The ability to review observational data before suggesting an explanation for the phenomena being observed makes semi-structured observations a reliable method (Cohen et al., 2000).

Concerns and challenges

Using observations to collect data raised some issues. First, students might behave differently and may not reveal their actual use of the technology because they are affected by the observer's presence. This problem was overcome here by ensuring that the student was unaware of being observed (Robson, 2002). This was achieved by observing a group of students in a classroom, and concentrating on certain students at a certain time. In this case students are aware of being observed but they do not know when the observer is focusing on them, which may be a good approach if students forget about the observer and behave naturally. However, it may result in students being alert all the time and behaving differently. Also, the observer may misinterpret what students are doing or might be affected by past experiences. The researcher may not notice some detailed changes because of observing students for a long time. However, looking at the repeatability of observations over time can assess the recorded observations' reliability as it shows that the observed instances are not unique but happen all the time.

Observing students required obtaining their informed consent and assuring them that the gathered data will be confidential and only used for the identified research. In addition, students were made aware that their identities will be kept anonymous (BERA, 1992). Observing students also required getting the university's agreement to observe students in formal and informal settings. Permission to observe students in formal settings was also granted by instructors. In terms of observing students in informal settings, the researcher was opportunistic by observing students in these settings such as the library but only keeping and using the data when students' informed consent was obtained. Subsequently, these observations reflected on students' actual use of the technology because they were unaware of the researchers' presence; if the students were aware it might have caused them to act in unusual ways.

Data Analysis

The observational data was used to answer the research questions, by providing cases that reflect on this thesis's main issues of concern: (a) mobile learning, (b) learners' activities in formal and informal settings and (c) the relationship between context and learning activities. In terms of studying mobile learning, cases were extracted from the observational data and sampled by analysing all the cases using Sharples et al.'s (2007c) proposed properties of mobile learning and activity theory and then choosing a subset for inclusion in this thesis that illustrate the types of use observed. The analysis of each case study included a short description of what happened that was extracted from the observation notes, followed by a separate section for the case interpretation using the mobile learning properties and activity theory (discussed below). The analysis sheet format is presented in Appendix F. As will be seen in Chapter 5, the sampling technique was adjusted based on the experiences in the pilot study.

The observational data was also analysed using the concepts of activity theory. Activity theory principles helped in investigating students' learning practices that are mediated by the use of tools in different contexts showing the contradictions that occurred when using the portable devices and how students resolved them. In addition, activity theory principles enabled investigating the relationship between context and learning activities by examining learning activities in relation to their context.

For example, the observational data helped investigate the impact of instructors' portables utilisation on students' portable utilisation. This was studied by finding the common applications that students and their instructors use and the purpose of using these applications.

When students used the application for the same purposes as their instructors, influence may be implied especially in cases where instructors explicitly ask students to use certain applications of use certain resources. In addition, the findings from the observations were compared with the data in log files to check if students use the applications that instructors use in informal learning settings and for the same purposes. Students were also interviewed to find out the purpose of using the application and whether this matches with the purpose the instructors had when using the application.

Log files

Log files are files created by system monitoring software. They list a sequence of events that have occurred when a person uses a computer. The software runs in the background and records the type of software (applications) used and when they were used. In this thesis, log files were used to provide information about the utilisation of potables by students in formal and informal settings. They were also used to assess the validity and accuracy of the data collected through self-report methods (questionnaires and interviews). Students were also interviewed to clarify some issues that occurred in the log files such as the purpose of using some applications. The log files enabled studying mobile learning, students' portable usage in formal and informal contexts and to investigate the relationship between context and learning activities.

Two system monitoring software packages (Boss Everyware and Activity Logger) were installed in students' laptops; the applications can only be used to log activities on laptops. The selected software packages have similar features, logging the software applications a student runs, the time they were used, the time spent using them, internet usage and data entered via the keyboard; all stored in tables. Two factors helped in the decision of purchasing two system monitoring software packages. First, Activity Logger has a feature that is not available in Boss Everyware which is capturing screenshots of the students' device while in usage. This feature provided the researcher with a clearer image of students' portable usage especially determining the activities that a student is carrying out. Second, Boss Everyware shows students' keystrokes in the log file which can then be exported to spreadsheets for analysis, where Activity Logger only shows students' keystrokes when the log file is exported to an HTML format which is not useful for analysing the data. More information about the applications is available in Appendix E. (As will be seen in the pilot study chapter, discussed in Chapter 5, Activity Logger was sufficient for investigating students' activities because, as discussed above, it provides a clearer image of the student's technology utilisation which could not be accurately determined from the tables created by Boss Everyware. The tables

provide information of how long an application was running but they cannot determine whether the application was actually used or was just running while the student was using other applications.)

Concerns and challenges

Installing system monitoring software on students' laptops requires, for ethical reasons, obtaining students' informed consent. Students were notified of the reasons and the usage of the log files. Using log files raises other ethical issues such as protecting students' anonymity and privacy by keeping students' identities and the gathered data confidential (BERA, 1992). This was done by removing students' identification from the log files once retrieved and ensuring that the collected data is not accessible to anyone other than the researcher. Another concern is students' awareness of the software which may influence the activities that they pursue using the devices.

Data Analysis

The analysis of log files was mainly focused on the screenshots captured by Activity Logger. All the screenshots for a specific student were collected and placed in a folder. This helped with tracing the activities that the student pursued in different formal and informal contexts over a period of time. This also aided summarising the applications that students used in different contexts and the purpose of using them. The log files provided detailed information about students' utilisation of portables in formal and informal settings. They also helped with triangulating students' responses gathered through questionnaires and interviews, identifying the similarities and differences between students' portables usage in formal and informal settings and providing an idea about the relationship between the features of these settings and learning activities.

The screenshots were examined visually by inspecting each and filling in a form (Appendix G) that includes: date, time, application, purpose and notes. The form helped in determining the applications that the student used in formal and informal settings and the reason for that usage. (As will be seen, the collected screenshots also included a massive number (around 30%) of shots with no user activity; these were not analysed. In addition, the analysis of the screenshots in the second and third studies was done by scanning them and looking for the continuity of students' activities over time. This helped with studying mobile learning.) The physical context where learning activities took place was determined by comparing the time recorded on the screenshot with the students' timetable, and supporting that with observational data when this was available. However, in some cases, the physical context had to be inferred by studying the applications that students used, shown in log files, and the

activities that they engaged in. This provided an idea of the location where learning activities took place in relation to where they are supposed to be in the timetable. In some cases the physical context was determined by referring to students' online conversations with friends and family where they mentioned where they were.

Similarly to the observational data, cases were analysed using Sharples et al.'s (2007c) mobile learning properties to study mobile learning and activity theory. Activity theory helped with describing students' activities, identifying the contradictions that occur in the activity system and explaining how these were resolved. Analysing the cases using activity theory also helped with understanding the relationship between context and students' learning activities. Determining the location where learning activities took place helped with determining the context, physical and social features of these locations, and therefore understanding the relationship between context and learning activities. The interviews also helped with gathering information about the learning activities in log files and the contexts where these took place.

Interviews

Students were interviewed during and at the end of the studies to clarify issues arising from the observations and log files. Interviews have the advantage of enabling respondents to reflect on their experiences and recognise issues that otherwise may not be recognised, revealing issues that may not be visible during observations.

Semi-structured interviews were most appropriate for the studies in this thesis as this type of interview offers the interviewer the ability to modify the predetermined questions as well as the wording according to the interviewee. The interviews were structured based on the observational notes and log files and thus the questions varied according to what the interviewees had done with their technology. In addition, this allowed the interviewer to abandon inappropriate questions that might not suit the interviewee and at the same time the ability to add other questions (Robson, 2002).

Concerns and challenges

Like the questionnaire, the interview questions were designed to ensure the reliability and the validity of the collected data by taking care with the wording of questions, avoid leading or ambiguous questions and ensuring the confidentiality and anonymity of students' identities in the collected data.

Data Analysis

The interview data were mainly used to clarify some of the issues arising from the data collected by the other research methods. The data was also used to provide descriptions of some cases that clarify students' portables usage in formal and informal settings.

4.4 Conclusion

This chapter has set the methodological basis of the studies conducted in this thesis. It outlined the methodologies used in the area of the study and their features and limitations. The chapter also discussed some recommendations for operationalising activity theory which is the theoretical framework of this research. Moreover, the chapter outlined the methods and methodology used in each of the studies in this thesis. As illustrated, the studies involved mainly qualitative research methods, consisting of questionnaires, observations, log files and interviews. A detailed description was provided of how these methods were facilitated in the studies, how the collected data was analysed and how each research question was answered. A pilot study that implements the methodology proposed in this chapter is presented in the following chapter.

Chapter 5

Understanding Mobile Learning: A Pilot Study of the Use of Portable Devices in Higher Education

This chapter discusses a pilot study that examines the plan proposed in the previous chapter and determines how far it helps with answering the research questions, especially in understanding mobile learning and the factors that help with studying the concept. This chapter begins with a description of the study setting. This is followed by a description of the data collection, analysis, and the study findings. The discussion of what the study reveals about the research questions and analysis methods are presented later in the chapter.

5.1 Pilot study setting and sample selection

The pilot study was undertaken in October 2005 in a university in the United Kingdom where instructors mainly use traditional technologies such as over head projectors (OHPs) during lectures; others use laptops to present lecture slides. Students are usually given handouts to use during lectures and lab sessions to write down notes and solve exercises.

5.1.1 Formal settings

Students were studied in formal settings mainly during lectures. A number of instructors were approached via e-mail (Appendix B) to ask for their permission to conduct the study in any of their 2nd and 3rd year classes. Permissions from two instructors for two different courses (Computer Science and Physics) were granted. After that, students were approached and asked to take part in the study. They were also provided with information about the study. Students' participation included completing a questionnaire, being observed during lectures, installing system monitoring software on their laptops (if they have one) and being interviewed.

Data that reflects students' utilisation of portables in formal settings was obtained through observations of students during lectures. The questionnaires also provided a general idea about students' utilisation of portable devices in formal settings. Moreover, students' portables utilisation in formal settings was studied through log files that were collected from

one student's laptop who agreed to install the system monitoring software on his laptop. The student's log files were studied by searching for activities carried out in formal settings such as classrooms. These were determined by comparing the time that appears on the log files with the students' timetable to help determine where the activities have taken place. However, in some cases, determining the location was inferred by studying the applications that student used and the activities they engaged in. This provided an idea of the location where learning activities took place in relation to where they are supposed to be in the timetable. Below is a description of the two classes that were studied.

Computer Course

The class included 60 students. It ran for two consecutive hours a week with 20 minutes break in between. The two lectures were held in two different lecture theatres in the same building. The lecture theatres were equipped with both a data projector and an overhead projector (OHP). In some sessions the instructor used both projectors. During lectures, the instructor used his laptop to project lecture presentations which were also uploaded on the course website before the lecture for students to download or print. The lecture slides were uploaded as PDF documents with spaces next to each slide for students' notes. Although students were not required to print the slides, some did to be able to take notes as the instructor presents the course material. The instructor also provided students with handouts that included graphs and exercises that were used in each lecture. The material of the handouts was not available in the lecture slides.

During lectures, students would listen to the instructor's illustration, take notes either on their handouts or handbooks and solve exercises when required. Usually students were required to solve exercises either individually or collaboratively in groups of 2 or 3. The instructor then solves the exercise with students on the blackboard. The only portable technologies that students had were their mobile phones.

Physics Course

The class included 49 students. It ran for two hours a week, scheduled on two different days. The lecture theatre was provided with both a data projector and an overhead projector. This class was a traditional class where the instructor used the OHP to project transparency slides. Students had a handout that included material for the entire course. The handout included questions and spaces for students to fill in answers which were provided by the instructor as he illustrated a topic. Students were usually asked to copy the answers from the transparency slides to the specified spaces in their handouts. The only portable technologies available in this class were students' mobile phones.

5.1.2 Informal settings

Students' technology utilisation in informal settings was studied by observing students in the library laptop zone while they were using their laptops to engage in different activities. A total of 5 students were observed in the library. Students were also observed in the computer class before and after the lecture, and during the 20 minutes break between the two sessions. In addition, students' utilisation of portables in informal settings was studied through the log files collected from a student's laptop by searching for activities carried out in these settings which was determined by comparing the time when the activities took place with the student's timetable.

5.2 Data collection

The pilot study data was collected through questionnaires, observations, log files and informal interviews. Below is a description of the study's data collection. Table 5-1 provides a summary of the data collected in this study.

Table 5-1 Summary of the data collected in the study

Setting	Number of students	Method	Total gathered data
Formal	109		
Computer class	60	Questionnaires	3 students
		Observations	Four weeks Two hours a week
		Log files	1 student – total 4210 screenshots (a screenshot is captured every minute) in four weeks
		Interviews	1 student: face-to-face (5 instances – 15 minutes) Instant messaging software (3 instances)
Physics class	49	Questionnaires	2 students
		Observations	Three weeks One hour a week
		Log files	n/a
		Interviews	n/a
Informal	5		
Library laptop zone	5	Questionnaires	2 students
		Observations	30 minutes each
		Log files	n/a
		Interviews	5 students: face-to-face (5-10 minutes)

5.2.1 Questionnaires

The response to the questionnaire in this study was generally low. Students in the computer class were given the choice on whether to complete the questionnaire or not. They were asked to take a copy of the questionnaire before leaving the class and return them completed at the next lecture. 30 students took a copy of the questionnaire but only 3 returned them. Similarly,

all of the 49 physics class students had a copy of the questionnaire but only 2 returned them. Three of the students that were observed in the library laptop zone agreed to complete the questionnaire but only 2 returned them. Thus, a total of 7 students out of 79 completed the questionnaire in this study. A sample of a completed questionnaire is available in Appendix J.

5.2.2 Observations

The students were also observed in formal and informal settings to collect detailed descriptions of their utilisation of portable devices in different settings.

Formal settings

Students were observed inside the classrooms. The computer class students were observed throughout four weeks, two hours a week. The physics class students were observed throughout three weeks, one hour a week.

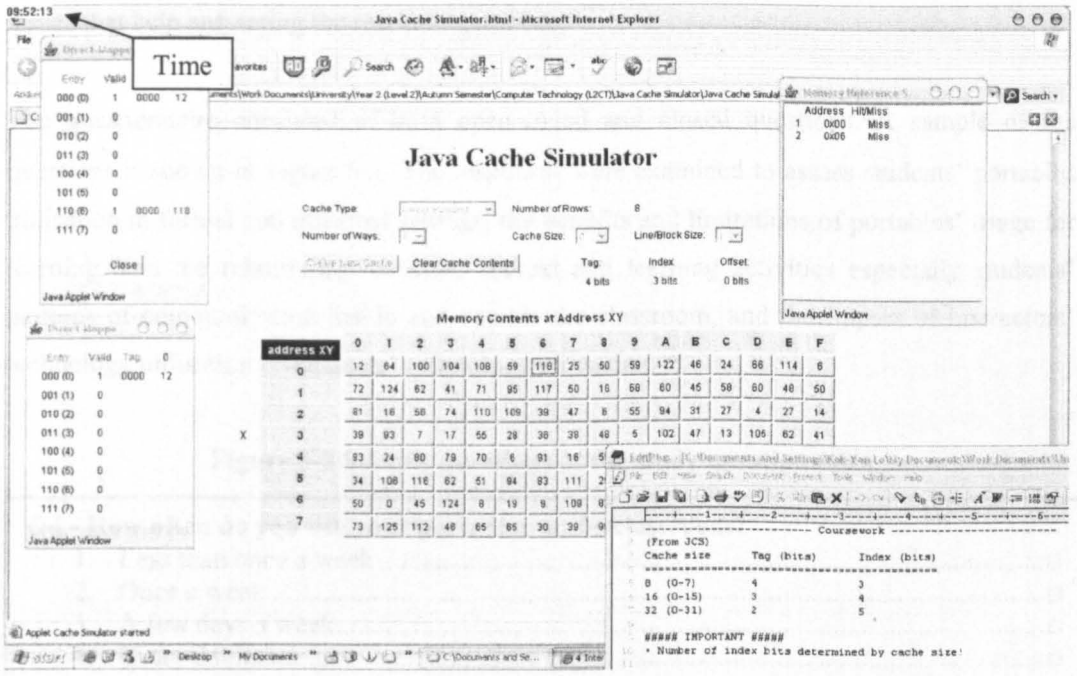
Informal settings

The students were observed in two different informal settings: the library laptop zone and in the computer class before and after the lecture and during the break between the two sessions. Three sets of observations were conducted in the library laptop zone; each lasted for around 30 minutes. Students were first observed then approached to ask for their permission to use the collected data for the study. All students agreed and signed the consent and authorisation form.

5.2.3 Log files

Only one student from the computer class agreed to install two system monitoring software (Boss Everyware and Activity Logger) on his laptop. The log files were collected by meeting the student in the university and copying them to an external storage device. In some cases, where the student was not available in the university, the files were downloaded from his website. A total of 4210 screenshots (a screenshot is captured every minute) were collected from the student's laptop over 4 weeks. Around 30% of the screenshots indicated no change in activity; some of which captured the screensaver. The file name helped with determining when the activities shown in the log files occurred. The file name comprised both the date and time. For example, the file name for the screenshot in Figure 5-1 is 051118_095213. The first part shows the date and the second shows the time. All screenshots were also time stamped, as in Figure 5-1. The log files mostly showed the student's activities in informal settings as the student did not use his laptop often during classes.

Figure 5-1 A sample screenshot produced by Activity Logger



5.2.4 Informal Interviews

A number of informal interviews were held with the student who agreed to install the system monitoring software on his laptop. The interviews were held either face-to-face during the log files collection meetings (5 instances each lasted around 15 minutes) or chatting online (3 instances). The interviews were held after the log files and observations analysis to help with clarifying some issues and findings. For example, the interviews clarified how often the student uses his laptop, where, when and why. The students that were observed in the library laptop zone were also interviewed to clarify some of the issues arising from the observations and collect general information about their utilisation of portables in formal and informal settings.

5.3 Data Analysis

This section describes the analysis of the research data that was gathered in this study.

5.3.1 Questionnaire analysis

The questionnaires were expected to act as a survey that provides information about the sample's utilisation of portables in formal and informal settings and help answering the research questions. However, the questionnaire's response rate was low (less than 10%) where the returned questionnaires did not represent the sample that was observed. Therefore,

the responses were not graphically presented but they were analysed as cases to look for issues that help answering the research questions.

The questionnaire consisted of both open-ended and closed questions. A sample of the questions is shown in Figure 5-2. The responses were examined to assess students' portables utilisation in formal and informal settings, the benefits and limitations of portables' usage for learning, and the relationship between context and learning activities especially students' patterns of communication inside and outside the classroom, and the impact of instructors' technology utilisation on students' technology utilisation.

Figure 5-2 Sample questions of the study questionnaire

Q4 - How often do you use your portables in the classroom?

1. Less than once a week ☐
2. Once a week ☐
3. A few days a week ☐
4. Every day ☐
5. Do not use ☐

Q5 - What are the applications that you use in the classroom?

1. Word Editor ☐
2. Presentation ☐
3. Spreadsheet ☐
4. Web browser ☐
5. Email ☐
6. Calculator ☐
7. Other (Please specify) .....

Q7 - Would you like to use your portables more inside the classroom?

1. Yes ☐
2. No ☐

If 'Yes'
Q7.1 - What stops you from using your portables more inside the classroom?

_____

_____

_____

_____

Q8 - What encourages you to use your portables inside the classroom?

_____

_____

_____

_____

5.3.2 Observational data analysis

Most of the pilot study data were derived from observations of students. The cases in the observational data were sampled by analysing all the cases and then choosing a subset for inclusion here that illustrated the types of use observed.

The sampling technique previously discussed in Section 4.3.3 was altered to reflect on the data collected in the study. The study included cases where students used portable technologies as well as conventional devices (e.g. handouts) to facilitate their learning activities. Thus, the cases were categorised based on two properties: the type of device used to facilitate learning (whether portable or conventional) and the type of learning this device assists (whether mobile or static). This was done by looking up a case to identify the type of the device that students used to facilitate their learning. The device would be a portable device such as a laptop, PDA or a mobile phone, or a conventional device such as a handout or a handbook. After deciding the type of the device, students' learning was analysed using the mobile learning properties proposed in Sharples et al. (2007c) in order to identify the type of learning that the device promotes. The properties are:

1. Learn across space as they take ideas and learning resources gained in one location and apply or develop them in another
2. Learn across time by revisiting knowledge gained earlier in a different context which then provides lifelong learning
3. Move from topic to topic by managing a range of personal learning projects instead of following a single curriculum
4. Move in and out of engagement with technology.

It is important at this point to re-state that the discussion of the mobile learning properties in this thesis builds on the research that Sharples et al. have published to date: (Sharples, 2005; Sharples et al., 2005; Taylor et al., 2006; Sharples et al., 2007a; Sharples et al., 2007c). In addition, Sharples et al.'s (2007c) discussion of these properties did not provide details as to how to use them as an analytical tool for studying mobile learning. This made the properties open to interpretation; this includes determining which of these should be met for learning to be considered mobile. In the discussion in the Findings section (Section 5.4), a case is considered mobile when it satisfies all of the four properties or static when it satisfies none of them. Section 5.5.2, provides a detailed discussion of the mobile learning properties and how the above assumption was reached.

As discussed earlier, the properties were argued to be useful to differentiate mobile learning from other types of learning activity. This developed four different categories which also form the sampling frame for including cases in the Findings section:

- Portable device – mobile learning
- Portable device – static learning
- Conventional device – mobile learning
- Conventional device – static learning

The classification helped with separating students' learning that is mediated by mobile and conventional devices, which showed how these devices facilitated and impeded students' learning practices.

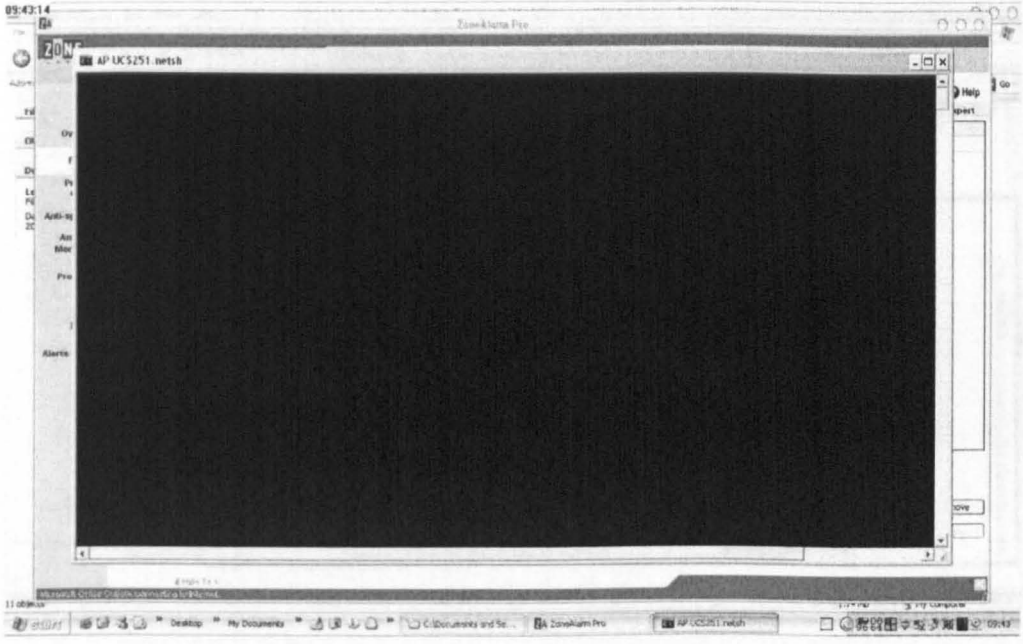
The pilot study cases were also interpreted using activity theory to analyse the activity system of these cases and identify any contradictions that might happen in the system, their impact on the system, and how students resolve them. As will be seen, resolving the contradictions in the activity systems enables students to use their portables to achieve the objective of the activity. Activity theory also helped with understanding the mobile learning properties. This is further discussed in Section 6.6.2.

5.3.3 Log files analysis

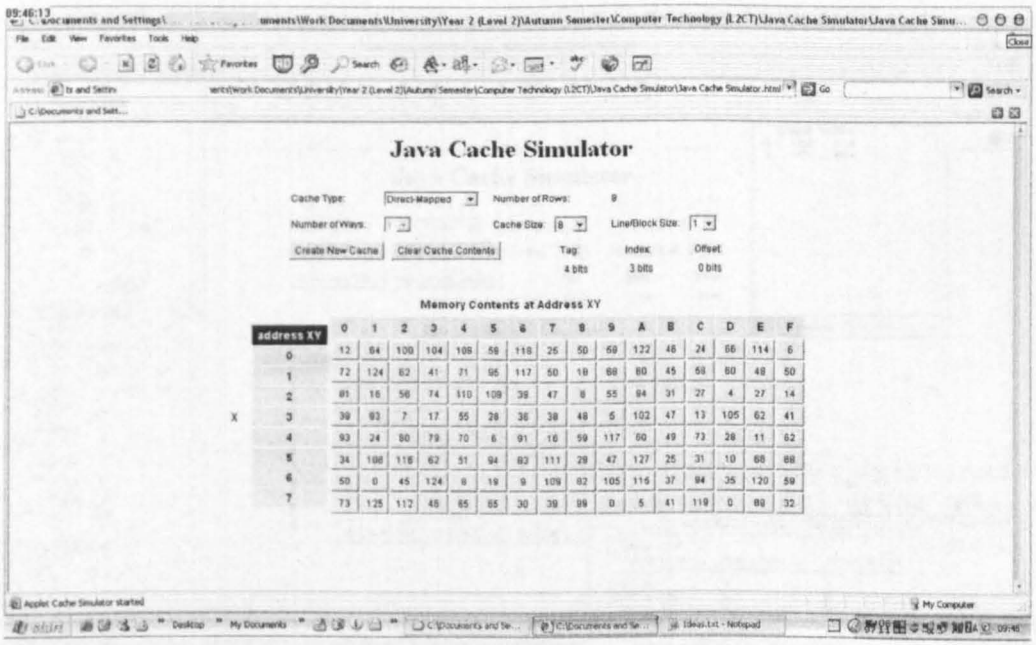
As discussed above, two system-motoring software tools were installed on a student's laptop to collect information about his laptop utilisation in different formal and informal settings. The collected data consisted of a group of tables (which both software packages created) and screen shots (which one of the software packages, Activity Logger, captured). The tables provided information about the applications that the student used and when (date and time) and how long they were used. The screen shots showed what exactly the student was doing as well as the date and time. A sample of some log files and how these helped with determining the activities a student carried out is presented bellow. The anonymity of the student was considered here by selecting screenshots that do not include any information about the student's identity or hiding the parts that may identify the student.

During a lab session

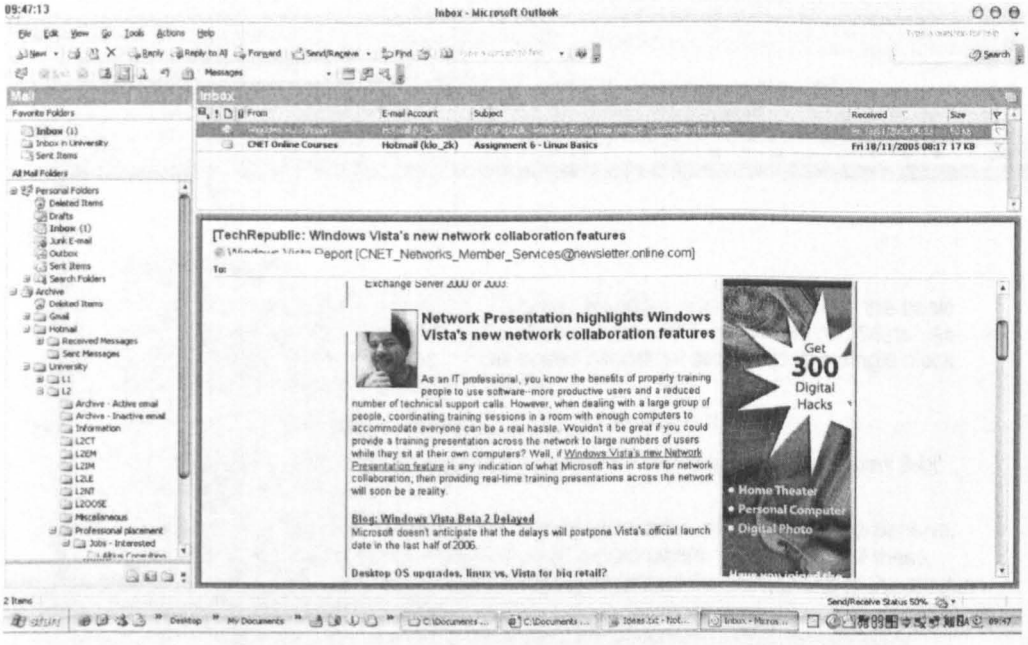
9:43 The student opens his laptop and tries to connect to the university wireless network



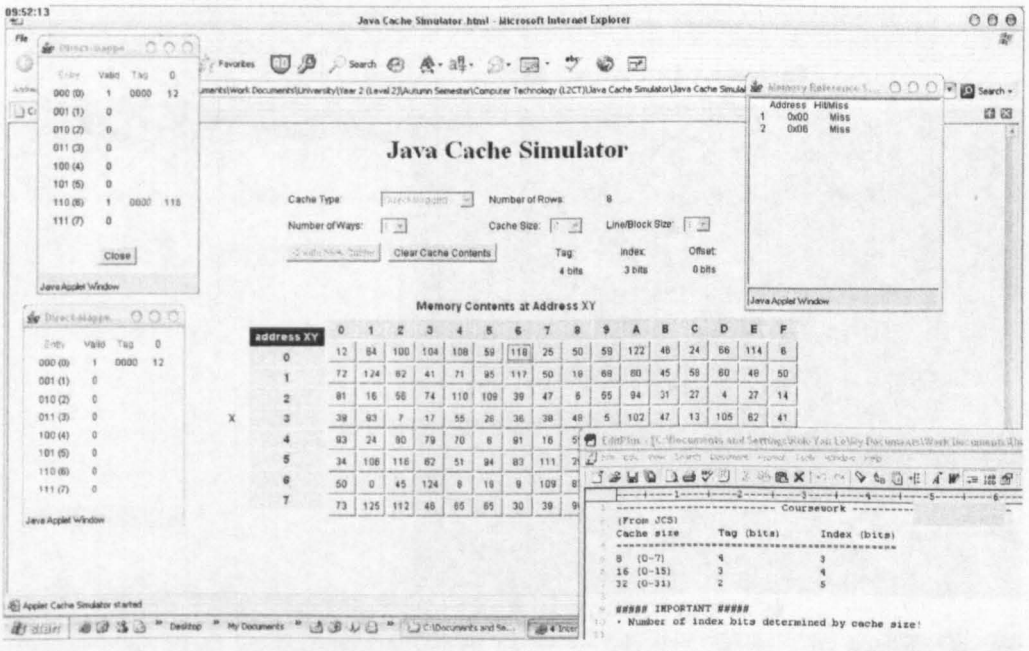
9:46 The student opens a simulator's web page



9:47 He is reading an email

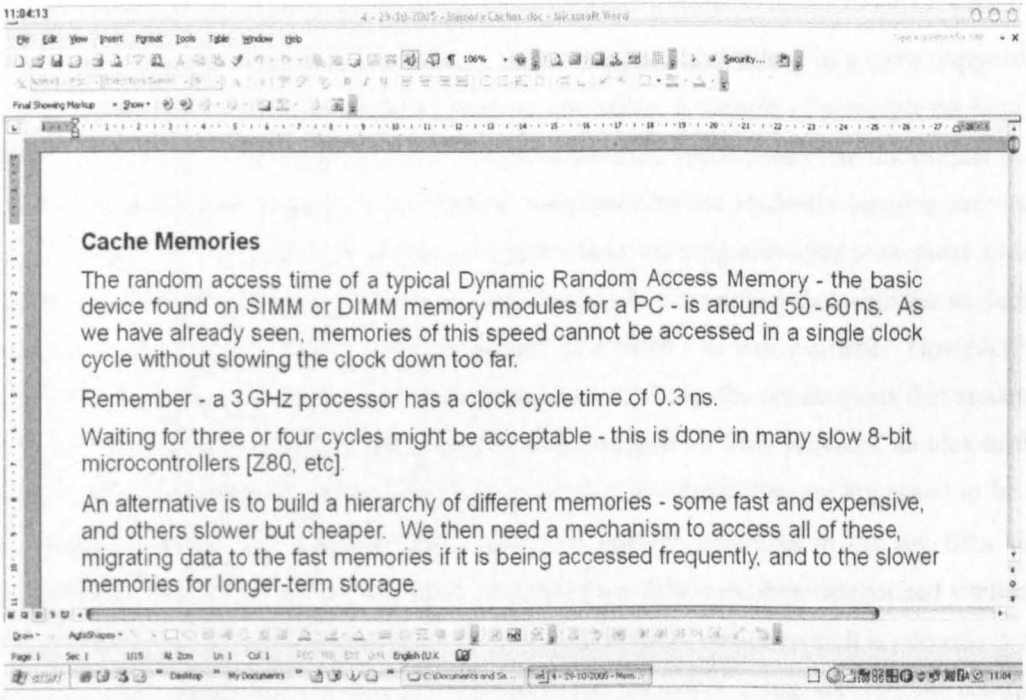


9:52 He starts the simulator and opens up an existing text document which includes a coursework's exercise and some text he has written regarding the coursework and the simulator

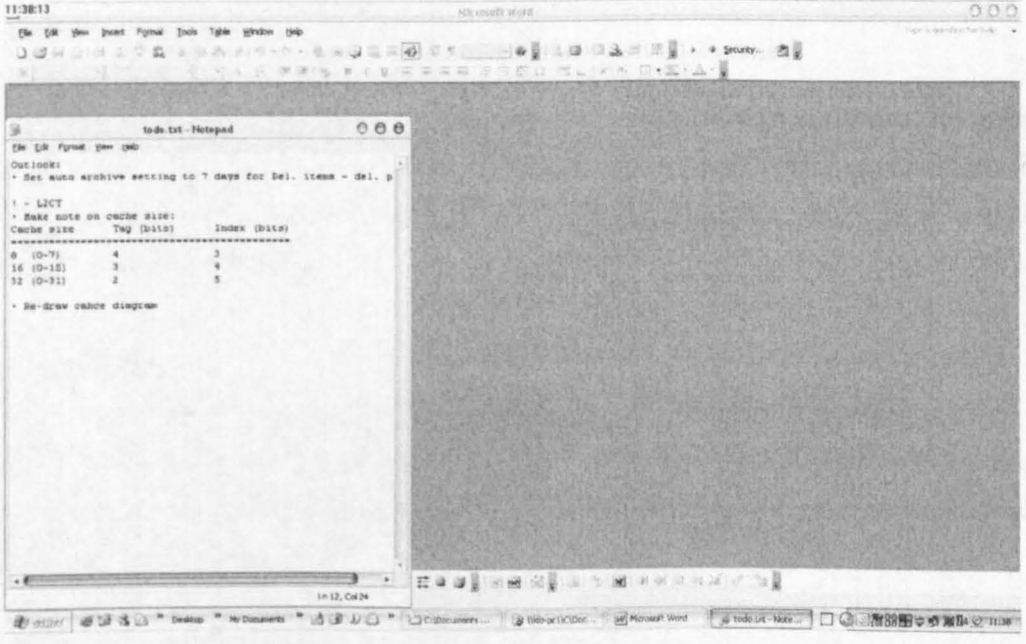


During his break

11:04 He is going through his lecture notes and writing comments



11:38 He is writing in a text file (To do) a task that he needs to accomplish



The log files analysis concentrated on analysing the captured screen shots because they provide a clearer image of the student's technology utilisation which could not be accurately determined from the tables. The tables provide information on how long an application was

running but they can not determine whether the application was actually used or was just running while the student was using other applications.

The screen shots were examined visually by inspecting each and filling in a form (Appendix G) that includes: date, time, application, purpose and notes. A sample of a completed form is shown in Appendix I. The form helped with determining the applications that the student used in formal and informal settings. It also helped with studying the student's learning activities that span different settings. The physical context where learning activities took place in the log files was determined by comparing the time recorded on the screenshot with the student's timetable, and supporting that with observational data when this was available. However, in some cases, the physical context had to be inferred by studying the applications that students used, shown in log files, and the activities that they engaged in. This provided an idea of the location where learning activities took place in relation to where they are supposed to be in the timetable. Determining the physical context of learning activities in the log files also helped with determining the social context. The collected data were then categorised similarly to the observational data analysis based on the type of the used device (which is portable in all the cases) and the type of learning that the device promotes using the mobile learning properties. The cases were also analysed using activity theory similarly to the observational data.

5.3.4 Interviews

The informal interviews that were conducted with the student that agreed to install the system monitoring software on his laptop and the students observed in the library were not formally analysed as they were used to provide clarification of some of the issues that were observed or found in the student's log files.

5.4 Findings

This section discusses the findings of the questionnaires, observational data and log files in separate sections to show the type of data each research method provides and how each helps with answering the research questions. Cases in this section were also clarified through the informal interviews data.

5.4.1 Questionnaires findings

As already discussed in Section 5.3.1, because the questionnaires' response rate was low, students responses were not graphically analysed but they were analysed as cases that help understand learners' activities in formal and informal settings and answer the research questions.

The questionnaire analysis showed that the students used their portable technologies outside the classroom more than using them inside the classroom. Students rationalise that to a number of factors. First, the setting of the lecture theatres such as the lack of space and power sockets which limited the use of the devices in formal settings. Second, personal preferences where students stated that they prefer to use their handouts during class to take notes than using laptops for the same purpose (difficult and time consuming) as it is easier and quicker. Third, students stated that the unnatural user interface of portable technologies especially for taking notes and drawing diagrams limits their utilisation in formal settings as taking notes is easier when using pen and paper. Fourth, students clarified that the lecture notes are provided in formats that can not be altered (e.g. PDF documents) using the laptops which limited the usage of portables for taking notes. The questionnaires showed that the students mainly used their portables outside the classroom for searching the Internet, working on essays and assignments, communicating with others, and referring to course related materials.

The questionnaires also showed that the students do not use their portables to communicate with others inside the class as they prefer to do that face-to-face to discuss and ask questions about the illustrated issues. They also showed that students communicate with others outside the class face-to-face to discuss issues illustrated inside the class and to keep in touch with friends and family.

Students also clarified that instructors' portables utilisation did not affect their utilisation of the technologies as instructors only used portables inside the class for presenting lecture slides. In addition, the tasks set by instructors did not encourage them to use portables.

The analysis of the questionnaires revealed the need to explore whether or not students use their portable technologies inside the class and the reasons behind that. In addition, the findings of students' questionnaires should be triangulated with data collected through observations and the log files collected from one of the students. Moreover, it is important for subsequent studies to investigate if these finding are replicated more widely over a larger number of participants.

Detailed students' questionnaire responses are provided in the table below (Key: CS: Computer Science class student, PHY: Physics class student, L: student observed in the library).

Table 5-2 Information extracted from students' questionnaires

Theme	Subcategory	ID	Example
Using portables in formal settings	Reasons that stop students from using portables inside the class	CS1, CS2, L1	'Too heavy' 'Lack of space in lecture theatres' 'Lack of power supply in lecture theatres/labs' 'Laptop's unnatural user interface' 'Prefer to use notes on paper'
	Reasons that encourage students to use portables inside the class	CS1, CS2, L1	'Make changes to original copies of notes' 'Convenience of having all your notes in one place' 'Having a system personalised to your own needs/preference' 'Easier and quicker'
Using portables in informal settings	Reasons that stop students from using portables outside the class	CS1, CS2	'Lack of power socket' 'Lack of internet connectivity that is free' 'Battery life'
	Reasons that encourage students to use portables outside the class	CS1, CS2, L1, L2, PHY1, PHY2	'Convenience to quickly lookup information (PDA)' 'Do coursework' 'Communicate with others' 'Check emails' 'Fun, easy, quick' 'Ease of use and accessibility to work'
Portables' influence on students' learning practices	Portables' influence on students' learning practices in formal settings	CS1, CS2, L1, L2, PHY1, PHY2	**Positive influences:** 'Easier and quicker to copy notes' **Negative influences:** 'Too complicated, requires effort' 'Distracts more than being helpful' 'Lecture notes are provided in a format that can not be altered' 'Lack of space in lecture theatres' 'Lack of power supply in lecture theatres/labs' 'Laptop's unnatural user interface'
	Portables' influence on students' learning practices in informal settings	CS1, CS2, L1, L2, PHY1, PHY2	**Positive influences:** 'Easy to carry around' 'Completion and alteration of assignments, other university work to be done effectively without being in the university campus' 'Do more research on the Internet' 'Access information easily' 'Have all your notes with you' 'Having a system personalised to your own needs/preference' 'Check email'
Portables and students' communication	Portables help students' communication	CS1, CS2, L1, L2, PHY1, PHYS2	'Saved time. 'Made interactions more frequent' 'Contact via instant messaging about topics covered in the class' 'Ask questions' 'Email family and friends – keeping in touch'
	Hindered students' communication	CS1, CS2, L1, L2, PHY1, PHYS2	Not available

The impact of instructors' technology utilisation on students' portable use	Instructors' use of technology given students ideas	CS1, CS2, L1, L2, PHY1, PHYS2	Not available
	Instructors' actions encourage/require students' technology utilisation	CS1, CS2, L1, L2, PHY1, PHYS2	'Provide course material on the Internet' 'Task set do not require using portables' 'Essays need to be word processed' 'Presentations encourage them to use portables'
	Instructors' use of technology prevented/dismounted students' portables utilisation	CS1, CS2, L1, L2, PHY1, PHYS2	Not available
The impact of the unavailability of portables	Laptop	CS1, CS2, L1, L2, PHY1, PHY2	'Will have to use remote access to my PC at home to access old course notes' 'Use USB thumb drive/internet to handle file storage' 'Would have to use university computers more' 'Dependence on email would have to be cut' 'Out of reach with friends' 'Would not be able to use the Internet for work purposes'
	PDA	CS1	'All personal information management (PIM) functions will have to go back to paper-based' 'Major impact on general convenience, general organisation of my life'
	Mobile phone	CS2, L2, PHY1, PHY2	'Not so much on my work, but I would find it harder to communicate with distant friends'

5.4.2 Observational data findings

This subsection includes the findings of the observational data. The cases presented here represent small segments of the observational notes that highlight particular instances of learning practices and whether learning in these cases is mobile or static. The cases are categorised based on the type of the used device (portable or conventional) and the type of learning this device promotes (mobile or static) using the mobile learning properties (MLP) discussed in Sharples et al. (2007c). The cases are also analysed using activity theory (AT) focusing on a small segment of the case to highlight any contradictions in the activity system, their influence on the system and how these are resolved.

To recap, Sharples et al.'s (2007c) mobile learning properties are:

1. Learn across space as they take ideas and learning resources gained in one location and apply or develop them in another
2. Learn across time by revisiting knowledge gained earlier in a different context which then provides lifelong learning

3. Move from topic to topic by managing a range of personal learning projects instead of following a single curriculum
4. Move in and out of engagement with technology.

Portable device – mobile learning

Case description:

This case took place in the library laptop zone.
- Two students are reading books and they have their laptops in front of them.

...
- One of the girls (S1) is using her laptop. She is scrolling down Word document.
- They are reading from the book that is placed in the middle between them, chatting together (laughing sometimes) and typing in the documents.
- S1 is reading from the book and then typing.
- S2 is also reading from the book and typing.

...
- After talking to the girls, they mentioned that they are working on a piece of coursework. One of them said that she uses her laptop in classrooms to view lecture presentations and write down notes. She said that she prefers to have her laptop with her so that she has all her documents when she needs them. She also mentioned that having her laptop will provide her access to the technology whenever she need and would not have to search for a PC in the university lab or library.

Interpretation (using MLP):

Focusing on one of the students in this case (S1), the student's learning is considered mobile because it satisfies all the mobile learning properties. First, the student edited an existing document that already had some content and is developing it in another location (library). Thus, the student is learning across space because she is working on a piece of coursework that has been initiated previously in different location(s) (e.g. home, classroom, etc.).

The student is also learning across time by revisiting knowledge (the coursework's word document) that was gained earlier in a different context. As discussed in Section 3.3, context can be the physical location where learning practices take place which in this case is the library laptop zone and the previous location where the coursework was edited. The features of these locations may be different which affects the student's utilisation of portables. Context can also be the social setting of learning activities which in this case may have changed as a result of the change of physical location such as a change in the rules (read from a book, chat with colleague and type) and roles (one reads/one writes/one chats) within the community engaged in achieving the object of the activity (working on a piece of coursework).

In addition, the student is moving from topic to topic and must have engaged in a range of personal learning projects since the last time she worked on the coursework. In between the student would normally be engaged in other learning projects.

The student also moves in and out of engagement with technology as she used it before to work on the coursework, has stopped using it and is now using it again to achieve the same goal.

Interpretation (using AT):

In this case, the activity system includes a student (S1) that is engaged in working on a piece of coursework (object) using her laptop (tool). The community in the activity system includes the student and her colleague and is governed by a set of rules (read from a book, chat with colleague and type) and division of labour (one reads/one writes/one chats). The student not only uses her laptop to aid the activity, she also uses a book. This case shows that the tool (laptop) originally used to carry out the learning activity does not help the student achieve the goal on its own. This introduces a secondary contradiction (shown in Figure 5-3) between the object (writing a piece of coursework) and the tool (laptop) in the activity system which motivates the student to use other tools (books) to be able to resolve the contradiction (Figure 5-4) and achieve the goal (Figure 5-5). This kind of contradictions, as discussed by Engeström (1987), appears between the components of the activity system and are caused by the emergence of new factors, in this case a new tool.

Figure 5-3 The case's interpretation using activity theory

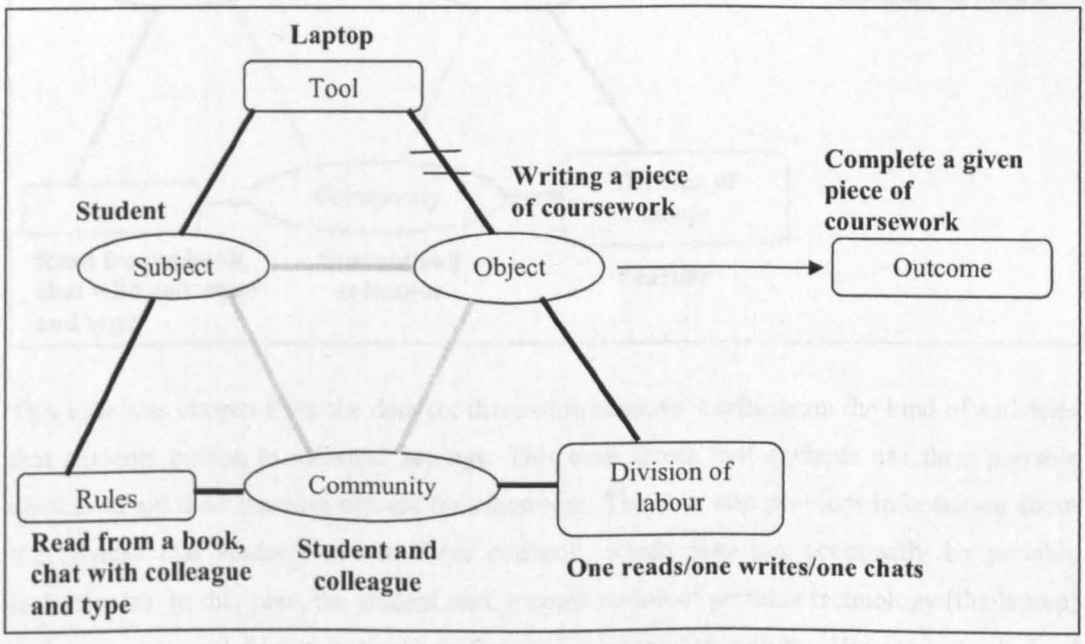


Figure 5-4 The case's interpretation using activity theory (continued)

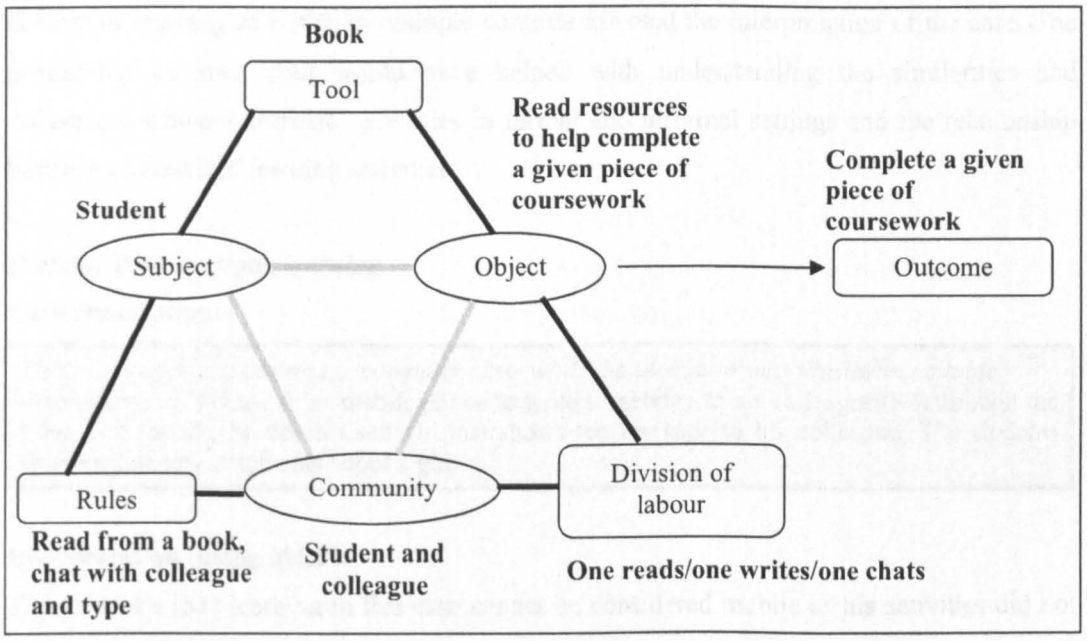
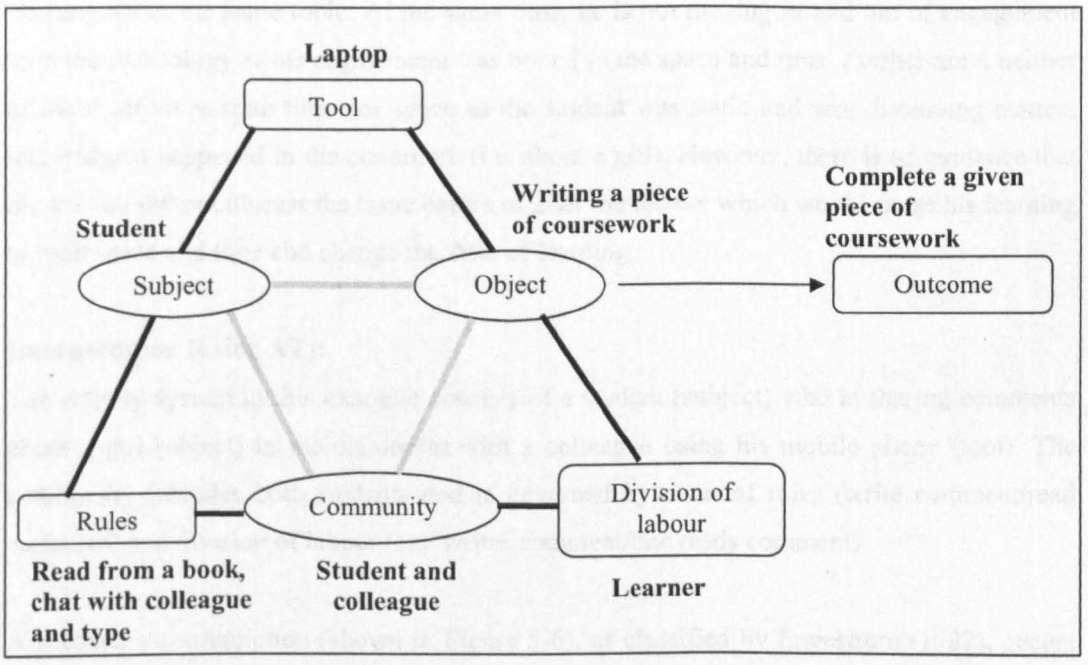


Figure 5-5 The case's interpretation using activity theory (continued)



This case was chosen from the data for discussion because it reflects on the kind of activities that students pursue in informal settings. This case shows that students use their portable devices to aid their learning outside the classroom. The case also provides information about the devices that students use in these contexts, which may not necessarily be portable technologies. In this case, the student used a combination of portable technology (the laptop) and a conventional device (a book) to facilitate her learning activity. However, the lack of

longitudinal observational data that might provide details on of the students' activities and the context of learning activities in multiple contexts affected the interpretation of the case. The availability of such data would have helped with understanding the similarities and differences between learners' activities in formal and informal settings and the relationship between context and learning activities.

Portable device – static learning

Case Description:

> *This case happened during the computer class while the instructor was illustrating a topic.* One student (S1) is using his mobile phone to write something to his colleague (S2) through the Messages feature, he doesn't send it, just shows the message to his colleague. The students were exchanging comments about a girl.

Interpretation (using MLP):

The student's (S1) learning in this case cannot be considered mobile as his activities did not support any of the mobile learning properties. In this case, the student is not moving from topic to topic by managing a range of personal learning projects as he was continuously chatting about the same topic. At the same time, he is not moving in and out of engagement with the technology as his engagement was bound to the space and time. Furthermore, neither of these activities span time nor space as the student was static and was discussing matters that had just happened in the classroom (i.e. about a girl). However, there is no evidence that the student did not discuss the issue before or after the lecture which would cause his learning to span space and time and change the state of learning.

Interpretation (using AT):

The activity system in this example consists of a student (subject) who is sharing comments about a girl (object) in the classroom with a colleague using his mobile phone (tool). The community includes both students and is governed by a set of rules (write comment/read comment) and division of labour (one writes comment/one reads comment).

A secondary contradiction (shown in Figure 5-6), as classified by Engeström (1987), occurs between the rules and the subject components of the activity system. The student (subject) subverts formal education by using his mobile phone to exchange comments with a colleague during the lecture. The student in this case changes the activity (chatting with a colleague) he is engaged in which also changes the rules (write comment/read comment) and division of labour (one writes comment/one reads comment) of the community (student and colleague) engaged in the activity. In this case, as the observations clarified, the rules in the classroom

required students to keep silent, listen to the instructor, take notes and answer when they are asked. The community included the instructor and students in the class and the division of labour is student/instructor. The student used the mobile phone to silently communicate with his colleague by writing texts instead of talking which might disturb others in the class and attract the instructor's attention. The student replaced the tool that is usually used for sharing comments inside the classroom (speech) with a portable technology that allowed him to share comments without disturbing others. The mobile phone was used to resolve the contradiction and enable communication without breaking the rules of the lecture (Figure 5-7).

Figure 5-6 The case's interpretation using activity theory

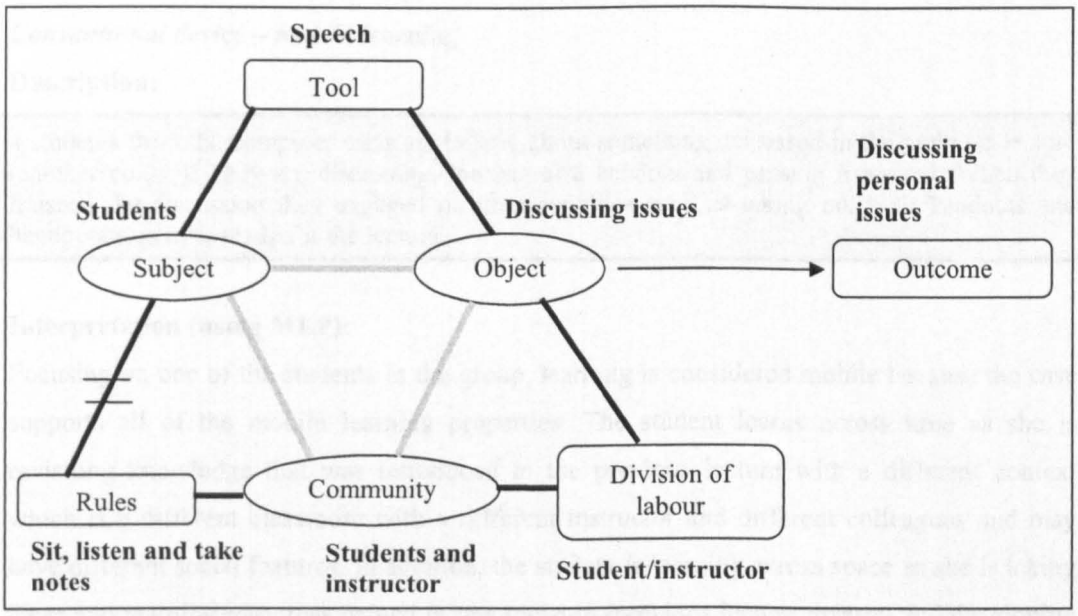
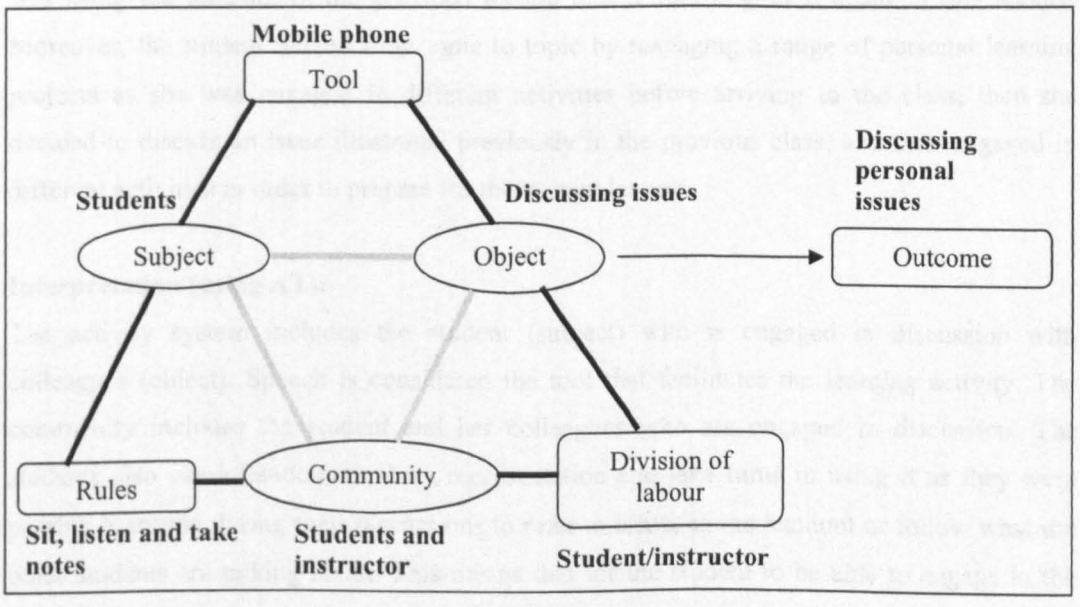


Figure 5-7 The case's interpretation using activity theory (continued)



This case was chosen for discussion to clarify that portable devices are not only used by students to mediate learning in formal settings, but also to subvert formal education. Changing the activity that students pursue in formal settings may also create different contexts than the lecture format that might be assumed to operate in this setting. The case also clarified that even if the device that students use to facilitate their activities is a portable device, learning may not be mobile. This is because their learning activities and their engagement with the technology, as in this case, was bound to the space and time of its usage which started and ended in the class. There was no evidence that this spanned space or time, nor other personal learning projects.

Conventional device – mobile learning

Description:

4 students from the computer class are talking about something discussed in the previous lecture (another course). They are discussing, looking at a handout and passing it around. When they finished the discussion they engaged in other activities such as taking out their handouts and handbooks, getting ready for the lecture.

Interpretation (using MLP):

Focusing on one of the students in the group, learning is considered mobile because the case supports all of the mobile learning properties. The student learns across time as she is revisiting knowledge that was introduced in the previous lecture with a different context which is a different classroom with a different instructor and different colleagues and may have different social features. In addition, the student is learning across space as she is taking ideas and learning resources gained in one location (previous lecture theatre) and developing them in another. The student is also moving in and out of engagement with technology as she was using the handout in the previous lecture and is referring to it again in this lecture. Moreover, the student moved from topic to topic by managing a range of personal learning projects as she was engaged in different activities before arriving to the class, then she decided to discuss an issue illustrated previously in the previous class, and then engaged in different activities in order to prepare for the current lecture.

Interpretation (using AT):

The activity system includes the student (subject) who is engaged in discussion with colleagues (object). Speech is considered the tool that facilitates the learning activity. The community includes the student and her colleagues who are engaged in discussion. The students also use a handout to share representation and take turns in using it as they were passing it around during their discussions to refer to issues in the handout or follow what the other students are talking about. This means that for the student to be able to engage in the

discussion she needed to refer to the handout. The community is governed by a set of rules (turn taking) and division of labour (one has handout/others have not). A contradiction (secondary) occurs in the activity system between the object (engage in discussion) and division of labour (one has handout/ one has not) of the activity system as the student can not achieve the goal unless she alters the division of labour (Figure 5-8). The contradiction in the activity system is solved when a student passes the handout around for those who need it (Figure 5-9). After resolving the contradiction, the student who asked for the handout will be able to successfully discuss the topic or follow others' discussions (Figure 5-10).

Figure 5-8 The case's interpretation using activity theory

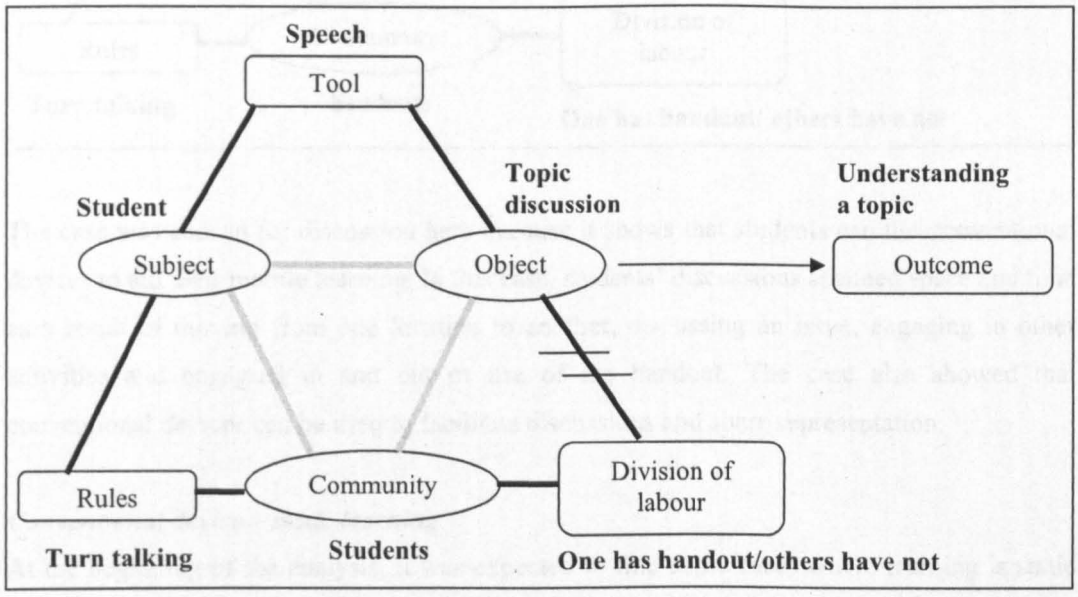


Figure 5-9 The case's interpretation using activity theory (continued)

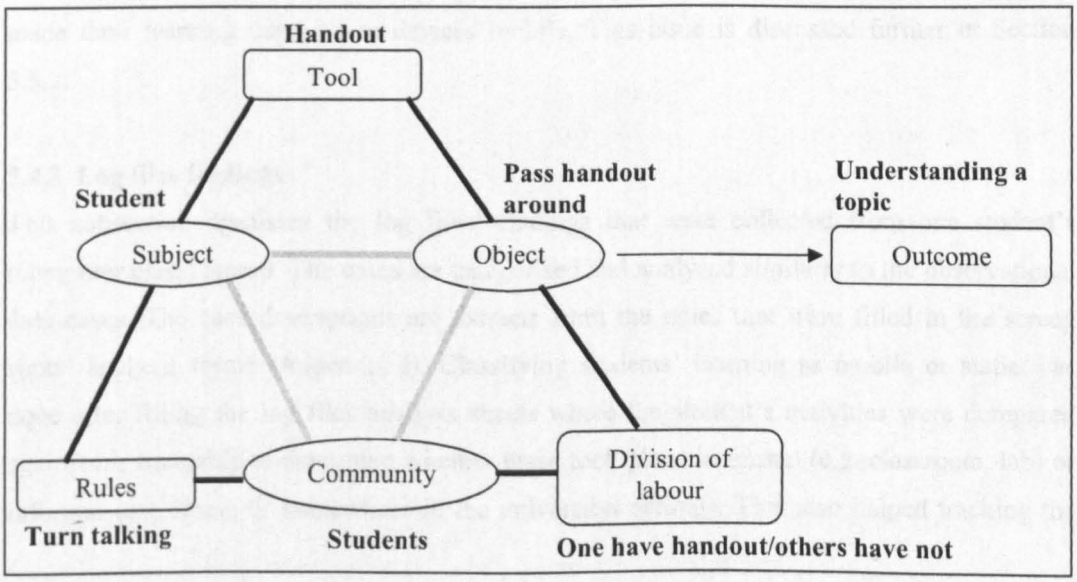
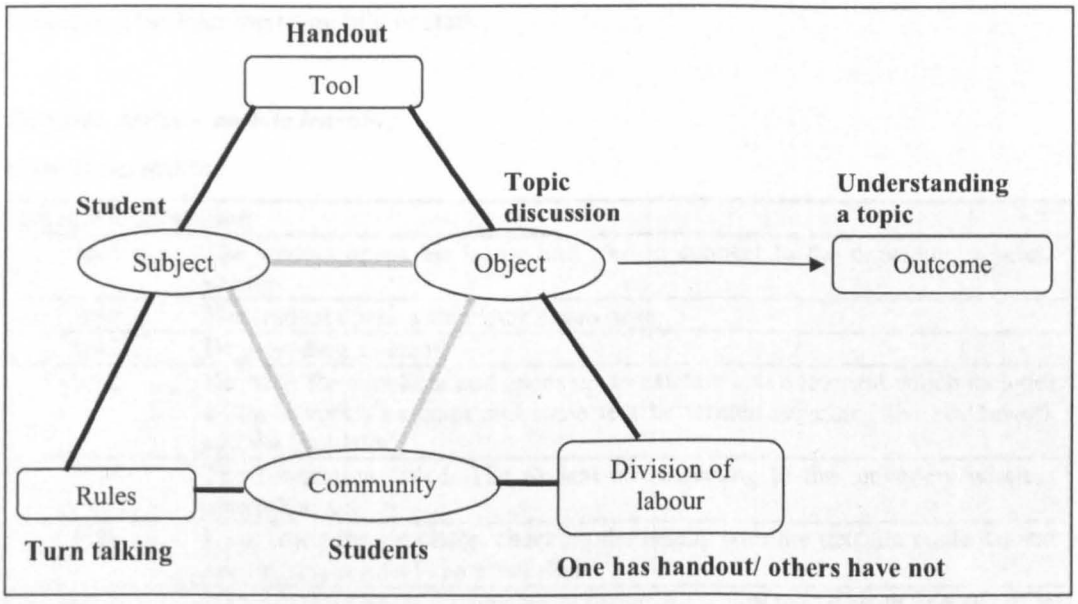


Figure 5-10 The case's interpretation using activity theory (continued)



The case was chosen for discussion here because it shows that students can use conventional devices to aid their mobile learning. In this case, students' discussions spanned space and time as a result of moving from one location to another, discussing an issue, engaging in other activities and engaging in and out of use of the handout. The case also showed that conventional devices can be used to facilitate discussions and share representation.

Conventional device – static learning

At the beginning of the analysis, it was expected to find some cases where learning is static when students used conventional devices to aid their learning. However, in most of the cases students used their handouts to refer back to issues that were discussed previously which made their learning using these devices mobile. This issue is discussed further in Section 5.5.2.

5.4.3 Log files findings

This subsection discusses the log files' findings that were collected from one student's (computer class) laptop. The cases are categorised and analysed similarly to the observational data cases. The case descriptions are extracts from the notes that were filled in the screen shots' analysis forms (Appendix I). Classifying students' learning as mobile or static was done after filling the log files analysis sheets where the student's activities were compared against his timetable to determine whether these took place in formal (e.g. classroom, lab) or informal (e.g. home or somewhere in the university) settings. This also helped tracking the

continuity of the student's learning activities in multiple contexts which helped with classifying his learning as mobile or static.

Portable device – mobile learning

Case Description:

During a lab session	
9:43	The student opens his laptop and tries to connect to the university wireless network
9:46	The student opens a simulator's web page
9:47	He is reading an email
9:52	He starts the simulator and opens up an existing text document which includes a coursework's exercise and some text he written regarding the coursework and the simulator
9:54	The connection failed. The student is connecting to the university wireless network again
9:57	He is using the simulator, checking the results with the text file contents, and copying the results to an excel sheet
10:07	He opens and alters a coursework document which was created and edited in the last few days
10:14	He goes back to the pasted data in the excel sheet, works on the simulator again and read from a website
10:28 – 10:50	He is reading through an assignment – related to the simulator
During his break	
11:04	He is going through lecture notes and writing comments
11:38	He is writing in a text file (To do) a task that he needs to accomplish
11:41	He is browsing the internet
11:46	Reads through the assignment sheet altered above
During a lecture	
12:04	He is going through some lecture slides
12:09	He opens the course's website to download some revision material
12:20 – 12:55	Opens the lecture notes, going through them and using the simulator
During a lab session	
13:38	He is viewing the downloaded revision material
13:58 – 14:08	Reading an online journal paper

Interpretation (using MLP):

The student's learning in this case is considered mobile as he learnt across space by working on an existing coursework document that the log files showed that he created and edited in the previous few days. The student also learnt across time as he revisited knowledge that was gained earlier (coursework document) in a different physical context. The social context of the activity may have also changed because of the change in the physical location. He also moved from one topic to another by managing a range of personal learning projects where the log files showed that the student used his laptop to carry out a number of activities during lab sessions, breaks and lectures. The topics that the student was engaged in were determined by the activities shown in the log files. In this case, the student was managing a range of activities throughout his movement across space. These activities also helped in identifying

the different personal learning projects that the student was carrying out (e.g. solving a coursework exercise using a simulator, browsing the Internet, checking his emails). The student also changed his engagement with the technology as he moved between classes.

Interpretation (using AT):

The discussion here focuses on a segment of the case discussed above. The activity system includes the student (subject) who is using his laptop (tool) to go through another course's revision material (object) while being in a lab session. The community engaged in the activity involves the student and is governed by a set of rules (read the revision material, read a paper) and division of labour (learner). The log files showed that the student subverted formal learning by going through another course's revision material during a lab session. This was determined by comparing the student's activities in the log files with his timetable to determine what activities he pursues during classes, lab sessions and breaks. The student's action introduced a contradiction (secondary) in the activity system as he was not following the rules in the lab session; he was expected to solve a lab sheet. This also changes the rules (listen to the instructor's illustration, and solve lab sheet) and the division of labour (student/instructor) of the activity of engaging with the instructor's illustration. The student acted as if he was following the rules by being in the lab and being engaged with his laptop. He used his laptop as a tool that enabled him to achieve his own goal without appearing to break the rules of the class (Figure 5-11 and Figure 5-12).

Figure 5-11 The case's interpretation using activity theory

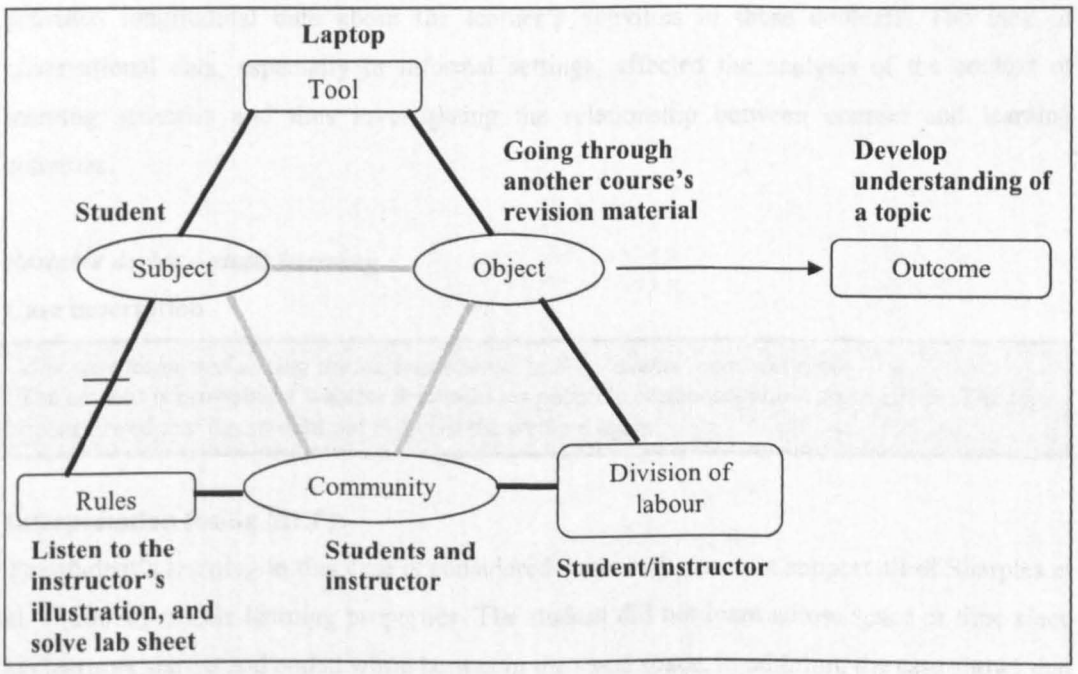
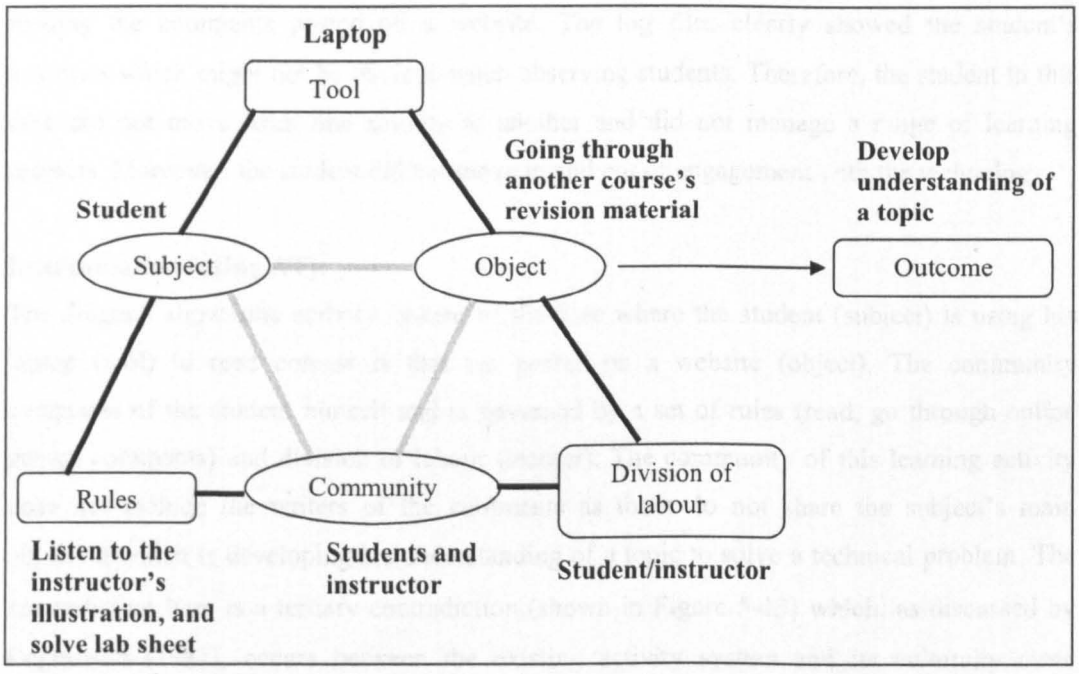


Figure 5-12 The case's interpretation using activity theory (continued)



This case was chosen for discussion because it illustrates that portable devices enable students to create contexts that the students using conventional devices could not create. In this case, the student could carry out activities and access learning resources that the students using conventional devices could not carry out or access. It was the existence of this kind of example that enabled the log files to be a useful tool that provide detailed descriptions of students' learning activities that take place in different formal and informal settings. They also provided longitudinal data about the learner's activities in these contexts. The lack of observational data, especially in informal settings, affected the analysis of the context of learning activities and thus investigating the relationship between context and learning activities.

Portable device – static learning

Case description

This case happened during the student's break in the students' common room.
The student is browsing a website that includes people's comments about some issues. The log files showed that the student did not visit the website again.

Interpretation (using MLP):

The student's learning in this case is considered static as it does not support all of Sharples et al.'s (2007c) mobile learning properties. The student did not learn across space or time since his learning started and ended while he was in the same space. In addition, the case shows that

the student in that instance did not move from one topic to another as the student was only reading the comments posted on a website. The log files clearly showed the student's activities which might not be obvious when observing students. Therefore, the student in this case did not move from one activity to another and did not manage a range of learning projects. Moreover, the student did not move in and out of engagement with the technology.

Interpretation (using AT):

The diagram shows the activity system of the case where the student (subject) is using his laptop (tool) to read comments that are posted on a website (object). The community comprises of the student himself and is governed by a set of rules (read, go through online posted comments) and division of labour (learner). The community of this learning activity does not include the writers of the comments as these do not share the subject's main objective which is developing his understanding of a topic to solve a technical problem. The contradiction here is a tertiary contradiction (shown in Figure 5-13) which, as discussed by Engeström (1987), occurs between the existing activity system and its culturally more advanced form and is caused by the object/motive of the new form of the activity which challenges the object/motive of the dominant activity. In this case, the object of the new form of the activity is finding a solution to a technical problem (the student not knowing about the topic). This motivates the student to resolve the contradiction by looking for a solution for the technical problem by browsing the web and reading other people's opinions and comments posted on a website (develop his understanding about that topic). This is shown in Figure 5-14.

Figure 5-13 The case's interpretation using activity theory

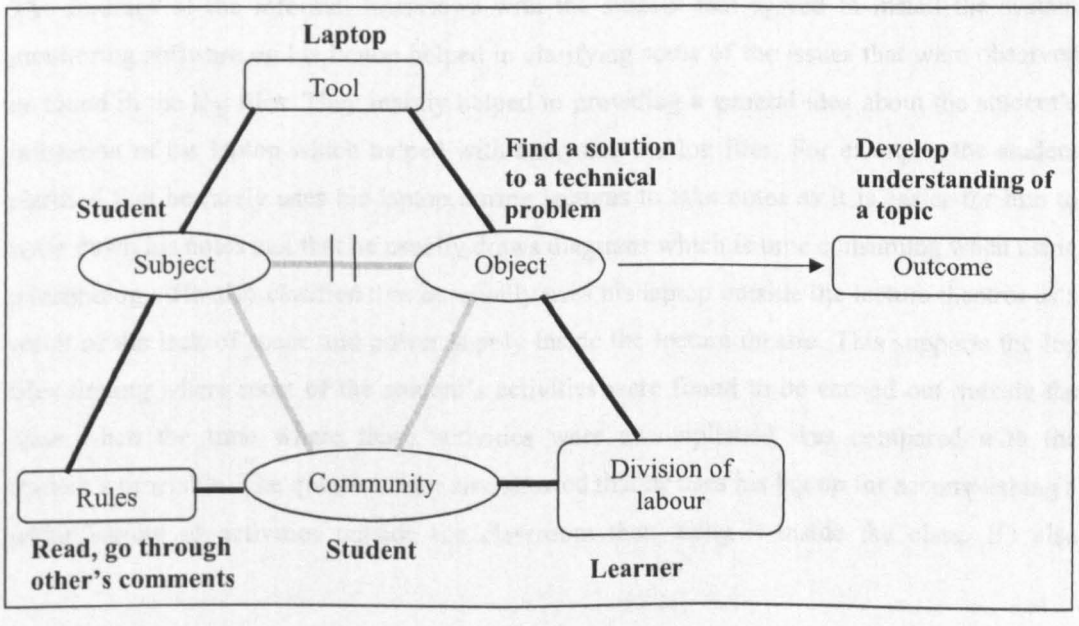
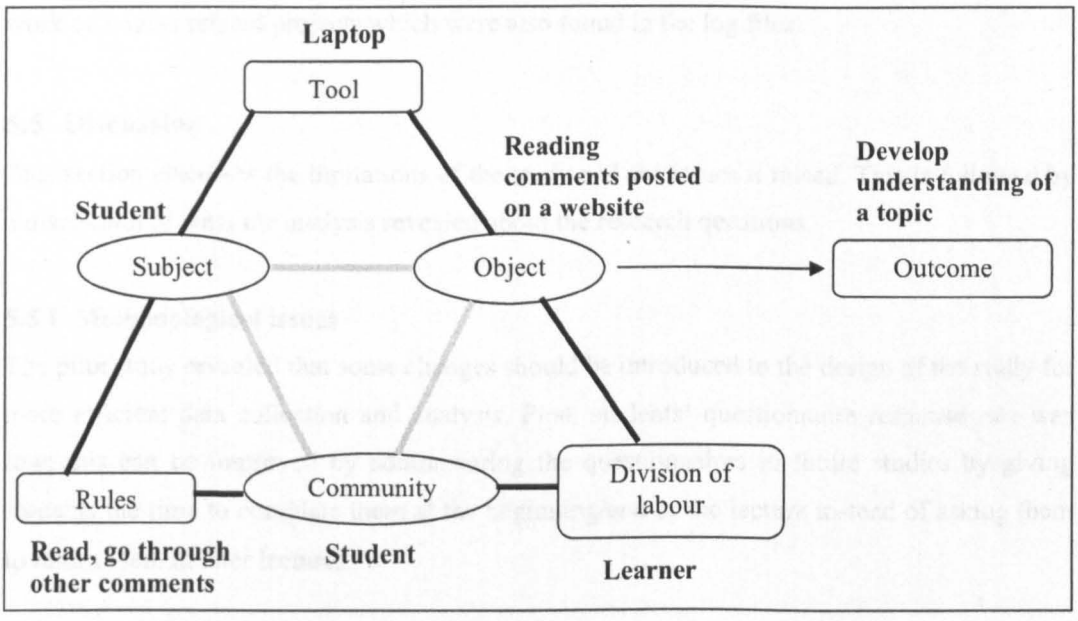


Figure 5-14 The case's interpretation using activity theory (continued)



The case was chosen to illustrate that portable devices not only aid mobile learning, but also static learning. However, in this case, the student's actions were isolated from the other activities that he was engaged in which made his learning in that instance static. But, if the case included the activities that the student was doing before and/or after reading the comments posted on a website, his learning would be considered mobile as he might have been reading to solve a problem he encountered previously. This case raises an issue regarding the definition of static and mobile learning which will be discussed in Section 5.5.2.

5.4.4 Interview findings

The findings of the informal interviews with the student that agreed to install the system monitoring software on his laptop helped in clarifying some of the issues that were observed or found in the log files. They mainly helped in providing a general idea about the student's utilisation of his laptop which helped with analysing the log files. For example, the student clarified that he rarely uses his laptop during lectures to take notes as it is easier for him to write down his notes and that he usually draws diagrams which is time consuming when using a technology. He also clarified that he usually uses his laptop outside the lecture theatres as a result of the lack of space and power supply inside the lecture theatre. This supports the log files finding where most of the student's activities were found to be carried out outside the class when the time where these activities were accomplished was compared with the student's timetable. The questionnaire also showed that he uses his laptop for accomplishing a wider variety of activities outside the classroom than using it inside the class. He also

mentioned that he uses his laptop outside the class to check emails, browse the Internet and work on course related projects which were also found in the log files.

5.5 Discussion

This section discusses the limitations of the study and the issues it raised. This is followed by a discussion of what the analysis revealed about the research questions.

5.5.1 Methodological issues

The pilot study revealed that some changes should be introduced to the design of the study for more efficient data collection and analysis. First, students' questionnaire response rate was low; this can be improved by administering the questionnaires in future studies by giving students the time to complete them at the beginning/end of the lecture instead of asking them to return them in later lectures.

Second, a problem that was encountered while analysing the observational data is the lack of adequate detail in the description of the cases. The observational notes would have been more useful in the analysis, especially understanding mobile learning, if they provided in-depth detail about students' learning activities that took place in and across formal and informal settings. In addition, having detailed descriptions of the context of learning activities, especially in informal settings where the researcher is not able to observe learners' practices, would have helped with understanding learning activities and context and the relationship between them, which this thesis aims to study. For example, in the study, having more detailed description of the learning activities that took place in informal settings would have helped with understanding the differences between context in formal and informal settings and how this affects students' practices in these settings. To solve this problem for future studies, more efficient ways to collect the observational data should be introduced such as video recording the lectures. This requires getting students' authorisation and avoiding video recording those who would not wish to be video recorded by asking them not to sit in front of the video camera. Video recording lectures will provide a baseline for referring back to unclear points that may arise in the observational notes.

The pilot study also showed that collecting log files from students' laptops is an effective data collection method because it provides details about students' learning activities that the other research methods (e.g. observations, questionnaires and interviews) could not provide, such as in-depth detail of students' learning activities in formal and especially informal settings. The study also showed that log files can be used to obtain longitudinal data about learners' activities in multiple contexts which aids studying mobile learning. However, the log files

collected in this study were from one student only. Having log files from multiple participants would have helped with getting a broader idea about students' learning activities in different settings and thus deeper understanding of mobile learning and the relationship between context and learning activities. Subsequent studies were planned to collect log files from multiple participants.

Another problem that was faced when analysing the log files was the lack of observational data, especially in informal settings, that supports the learner's activities in these contexts and data about the context of these activities. These were essential to understand the learner's activities shown in the log files and understand the relationship between context and the learning activities. Thus, subsequent studies will aim at observing students in both formal and informal settings.

The log files also showed that studying mobile learning requires studying students' portables utilisation in different settings. According to Sharples et al. (2007c), one of mobile learning properties is that learners move from topic to topic by managing a range of personal learning projects. However, the study revealed that the topics that students are engaged in cannot be easily identified over time and they cannot clearly identify students' learning projects. For example, in the observational data analysis it was not clear when students move from topic to another even when students moved across space as they may keep working on the same topic while they are moving across these spaces. Log files were helpful in identifying a solution for that as they clearly showed students' activities which also provide a clear picture of the topics that students are engaged in. Log files were also helpful in terms of tracking students' activities over time which helped in determining students' learning projects thus determining whether or not students' learning is mobile. This issue is further explained in the next subsection. Moreover, the log files helped with understanding the definition of context that is suitable for studying mobile learning and the relationship between context and learning activities. As will be seen in the next section, understanding context helped understanding the mobile learning properties.

5.5.2 Analytical problems

The pilot study revealed some limitations of the approaches used to analyse the data. Following is a discussion of these limitations and how they could be minimised.

Reflections on the use of activity theory

The pilot study showed that using activity theory helps with understanding learning activities and investigating the contradictions that occur in these activities, how students handle them

and their impact on the activity. Resolving the contradictions in the activity systems helped students to use their portable devices to achieve the objective of the activity. The study also clarified that collecting in-depth data about students' learning activities in different contexts, including information about the context of learning activities, enables studying the similarities and differences between learning activities that take place in formal and informal settings. This helps to understand the relationship between context (physical and/or social) and learning activities which this thesis aims to investigate. At this stage, the lack of detail about learners' activities in informal settings, which would complement their activities in formal settings, hinders drawing the similarities and differences in learners' activities that take place in these contexts.

Reflections on the mobile learning properties

The mobile learning properties discussed in Sharples et al. (2007c) were used in the pilot study to classify learning in the cases as mobile or static. The properties were helpful as an initial step to understand mobile learning. They provided an insight into the factors that differentiate mobile learning from other types of learning activity. However, the initial analysis showed that these properties require deep interpretation because it was not obvious whether satisfying one criterion is sufficient for studying mobile learning, or if all the four properties need to be satisfied, or whether some combination is necessary. At the beginning of the analysis, learning in a case was considered mobile when the case satisfied at least one of the mobile learning properties and static when it did not satisfy all the properties. However, this approach proved to be problematic as learning in almost all the pilot study cases was classified as mobile, even the cases where students' learning started and ended while they were in the same location, which intuitively makes their learning static. The only case where students' learning was considered static was a case where a couple of students used a mobile phone to subvert formal education by writing comments to each other during the lecture. Learning in this case was considered static because it did not support any of Sharples et al.'s (2007c) mobile learning properties. However, it was not clear whether students have discussed the matter in other contexts which would have helped in determining whether they learned across space and time (Sharples et al.'s (2007c) mobile learning criteria 1 and 2). This would re-classify learning in this case as mobile. The initial analysis showed that satisfying a single property could not classify mobile and static learning.

In addition, the properties were found to be interrelated where some properties occurred as a consequence of others which also made some cases satisfy more than one property and it was not obvious which properties are more important for classifying mobile learning than others. Furthermore, the broad approach in some details of interpretation needed to be changed to

count for things that happen in a significant way. For example, in this pilot study, students were considered to be moving in and out of engagement with technology by simply focusing and looking at their portable devices and then looking away while being in the same location. Similarly, students were considered moving from topic to topic by engaging in multiple activities at the same time while still being in the same physical location such as using their portables to write notes and chat with colleagues during a lecture. Moreover, there were some border line cases which could not be easily classified as mobile or static as it was difficult to determine which properties these cases satisfy.

It was also found that the mobile learning properties proposed in Sharples et al. (2007c) not only apply to mobile learning, they also apply to traditional education as students move between classes, learn at home and in the library by managing a range of personal learning projects and use portable and/or conventional technologies to aid their learning. This is based on the understanding that mobile learning occurs as a result of carrying out learning activities in different physical locations. The data analysis also showed that mobile learning not only happens when portable devices were an aid to learning, it can also happen when traditional devices, or a mixture of portable and conventional devices, are used to aid students' learning. Therefore, it is important to study students' mobile learning that is mediated by conventional devices which also might reveal important advantages and disadvantages of both devices when used to aid students' learning.

All the above issues led to a conclusion that for the empirical work in this thesis the mobile learning properties need to be reformulated to help in classifying learning in the case studies. This section discusses how these properties should be used to interpret the case studies by discussing each of the framework's criteria and proposing some changes that will help better distinguish these types of learning. This will also reveal the relationships between these criteria which will help in deciding which of these needs to be satisfied for students' learning to be considered mobile. But first, here is a discussion of some of the framework's terminologies to solve some of the ambiguities these might cause.

General Points about terminology

Ideas, knowledge and learning resources

In the mobile learning criteria proposed in Sharples et al. (2007c), students' learning is considered mobile when they develop ideas and learning resources across space in the first criterion, and revisit knowledge across time in the second. The researchers referred to ideas, knowledge and learning resources as means for students' learning across space and time. These terminologies are clarified here to detail how they were understood in the study.

First, knowledge and ideas are neither tangible nor mobile, but learning resources are both tangible and portable as students can carry them around to be used to aid their learning across space and time. This shows that learning resources are viewable empirically while ideas and knowledge are not. Second, ideas and knowledge may be misinterpreted. To solve this, referring back to constructivism helps understanding the concept of ideas and knowledge and how these aid students' learning. Constructivism is a theory of learning which claims that students construct knowledge rather than just receive and store knowledge from lectures and books. This means that each learner recursively constructs a personal version of the received knowledge based on knowledge (facts, ideas and beliefs) that he/she already has (Papert and Harel, 1991). This shows that both ideas and knowledge are important for students' knowledge construction and they should not be separated as in the mobile learning properties. Therefore, in the first criterion ideas will be replaced by knowledge as they can be considered a subset of students' knowledge. However, should students take knowledge and learning resources gained in one location and apply or develop them in another for learning to be classified as 'mobile'? How will it be determined that students referred back to knowledge since this is not viewable empirically? If referring back to knowledge is sufficient for students' learning to be considered mobile, then, from a constructivist perspective all learning must be considered mobile as learners always refer back to and develop what they already know. This was also found in the pilot study data analysis as learning in most of the cases was 'mobile'. For example, when an instructor illustrates a new set of handouts, the contents of the handout are in one way or another related to what was previously described in earlier lectures as all lectures will be interrelated to serve the aim of the course. Students in these cases are using their knowledge and ideas to understand the new topic, even if they are not referring back to any physical resources. Therefore, for empirical reasons, learning resources can be considered only as the knowledge that is formulated as some tangible means such as notes, books, video, etc. This ensures that students return back to some tangible resources to gain knowledge and develop it across space. This conceptualisation of learning resources is reviewed in Section 6.6.2 to clarify what learning resources should encompass which also helps with understanding and conceptualising mobile learning in this thesis. As a result, based on the discussion above, the first mobile learning criterion proposed by Sharples et al. (2007c) can be altered to consider students learning across space by taking *learning resources* gained in one location and applying or developing them in another. The same applies to the second criterion as students can be considered learning across time when they revisit *learning resources* gained earlier.

Context

Sharples et al. (2007c) use context as a mean for classifying students' mobile learning. They argue that students' learning can be considered mobile when they revisit learning resources gained earlier in a different context. As discussed in Section 3.4.3, context is considered one of the key concepts of activity theory. Engeström (1993) sees context as the activity system which integrates the subject, the object and instruments (material tools as well as signs and symbols) into a unified whole. His definition of context enables understanding human activities in terms of the relationship between the individual and the tool used, and the influence from the social grouping that the subject belongs to. Different conceptions of context in social and technological research have also been discussed in Section 3.3. The discussion showed that the conceptions of the term context tend to separate the physical features of the environment where learning takes place and the social setting of the learning activities. A question was also raised in Section 3.4.3 about which understanding of 'context' is most useful to study mobile learning. Here is a discussion of whether any one of these conceptions is sufficient for studying mobile learning or both are required.

The first conception implies that the context of learning activities changes as students change their location, which is also a requirement of mobile learning. This conceptualisation of context, as different locations, is sufficient for students' learning to be considered mobile. However, it discards the social context caused by carrying the learning activity in that specific location which may affect the learning activities. This was also found in this study as the lack of details about the social context affected the understanding and analysis of the case studies. The second conceptualisation implies that the context of learning activities changes when there is a change in the social setting of the learning activity that the students pursue. This can be as a result of a change in the social features, including the rules and roles that govern the community engaged in the learning activity. But what if changes occurred in the rules and roles of the community engaged in the learning activity, without a change in the location where learning activities take place, which is a requirement of mobile learning? Can students' learning be considered mobile? For instance, two students were in the classroom and listening to the instructor, and then they started discussing some issues illustrated earlier using their handouts. In this case, the social context of learning activity has changed as a result of the change in the activity pursued which caused changes in the rules and roles of the community engaged in the activity. Students in the case are referring back to learning resources gained earlier (a few minutes ago); however they are still in the same place. Can student's learning be considered mobile? Students' learning in this case cannot be considered mobile as a requirement of mobile learning is that students carry out their learning activities in multiple locations. This also raises the question if students' learning is considered mobile when they

revisit learning resources gained in one location and apply or develop them in the same location but in different times after experiencing different locations too? In this example, the physical context is unchanged, but the social context may be different as a result of changes in the social setting. This issue can be further investigated in subsequent studies.

Therefore, based on the discussion above, context in this research is considered as *both the physical and social setting of learning activities* as both are important to understand learning activities. This answers a question that was raised in Section 3.3 about which conception of context is best for this field of research. The conception helps with considering not only the physical factors that influence learning activities but also the social factors. Consequently, from this point onwards, context is considered as the combination of the physical (location) and social (rules and roles of the community engaged in the learning activity) contexts of learning activities. This also influences the understanding of the mobile learning properties (especially the first and second) where 'location' and 'context' are considered the key factors of these properties. This is discussed further below.

Sharples et al.'s (2007c) mobile learning properties discussion

Below is a discussion of the mobile learning properties proposed by Sharples et al. (2007c). Each of the four criteria is discussed separately and relationships between these are sought to determine which criteria should be met for students' learning to be considered mobile.

1. Learners learn across space as they take ideas and learning resources gained in one location and apply or develop them in another

As discussed above, students will be considered learning across space when they take *learning resources* gained in one location and apply or develop them in another. This criterion is problematic when interpreting *'gained in one location and apply or develop them in another'*. This can be understood as learners being in two (a) physically different locations or (b) different contexts. Which of these interpretations is sufficient for students to be considered learning across space? The first interpretation requires students to take learning resources gained in one location and apply or develop them in another. This ensures that students' learning spans different physical locations as they move from one location to another which also distinguishes mobile learning from any other form of learning (Sharples, 2005). In addition, learning across different physical locations may result in learning across social contexts as a result of the changes in the social context of learning activities in these locations. This supports the notion of context discussed previously. Therefore, the first interpretation shows that changing locations is sufficient for students to be considered learning across space. The second interpretation requires students to apply or develop learning

resources in two different contexts. Context, as discussed above, should be considered as the combination of the physical and social contexts of learning activities. This ensures considering the social factors that influence and are influenced by learning activities that take place in different physical locations. Therefore, this criterion can be altered to consider students learning across space when they revisit learning resources gained in another context.

Because Sharples et al. (2007c) did not provide details on how to interpret the mobile learning properties, this made them open to interpretation. Thus, analysing the first criterion, supported by the experience of using the criterion to analyse the data in this study, showed that learning across space causes learning across time. This is because a requirement of mobile learning is that learners' activities take place in different physical locations which also causes their learning to take place at different times too. Changes in the physical location also lead to students engaging in different activities that aid a range of personal learning projects and changes students' engagement with the used device. This implies a relationship between space, time, students' activities, and students' engagement with their devices which are also the factors that control the first, second, third and fourth criteria. As a result, satisfying the first criterion automatically satisfies the three other criteria which means that satisfying the first criterion is sufficient for students' learning to be considered mobile.

2. Learners learn across time by revisiting knowledge gained earlier in a different context which then provides a framework for a lifetime of learning

As discussed above, students can be considered learning across time by revisiting *learning resources* gained earlier to aid their learning. This criterion also links time to 'context'. As discussed in the terminology section above, studying mobile learning requires considering both the physical and social contexts of learning activities. Revisiting learning resources that were gained earlier (learn across time) in a different context implies that students are learning across space by engaging in learning activities in different physical locations and considering the social context of learning activities. This shows the relationship between time and space, which are the factors that control the first and second criteria. Time and space are also considered a subset of context focusing on where and when students' revisit learning resources. Thus, learning across different physical contexts implies that students may experience different social contexts as well because each location has a different social context. In addition, the social context of the same location may change each time students experience engagement with this location. This issue is further investigated in the subsequent studies.

As a result, the first and second criteria can possibly be joined considering students to learn across *context* when they revisit learning resources that were gained in another context; considering context as the physical and social setting of learning activities. In addition, when students are learning across context they will be moving from activity to another, and moving in and out of engagement with the learning resource. This implies a relationship between time, space, students' activities, and their engagement with devices which changes as a result of students' movement across space. These are also the factors that control the first, second, third and fourth of the mobile learning properties.

In this criterion Sharples et al. (2007c) also argue that students learn across time when they refer back to knowledge (changed to learning resources) gained throughout the years, which means that when a student is referring back to learning resources gained a long time ago, he can be considered learning across time as the context would be different. But, what if a student is referring back to learning resources gained a few minutes or hours ago, if he has changed his location since? Can the student be considered learning across time? In this case learning is considered mobile because the student has been moving through different contexts.

The second criterion's discussion showed that it is interrelated with the first criterion and can possibly be joined as one criterion because for studying mobile learning a case only satisfies the second criterion when it satisfies the first criterion. This also led to satisfy the two other criteria (criteria 3 and 4) which as discussed in the first criterion are consequences of that criterion. This means that satisfying the merged criteria (first and second criteria) is sufficient for students' learning to be considered mobile.

3. Learners move from topic to topic by managing a range of personal learning projects instead of following a single curriculum

Sharples et al. (2007c) argue that for learning to be considered mobile learners should move from topic to topic by managing a range of personal learning projects instead of following a single curriculum. This raises a question about what are topics and personal learning projects. How can they be determined when observing students or examining their log files?

First, topics. What is a topic? Is it something that a student is doing? When can it be determined that a student is moving from a topic to another? Do students need to move from topic to topic across space and time? What if students moved across space and time but still choose to keep working on the same topic? In addition, since topics are not viewable empirically, how it can be determined that students moved from a topic to another? The log files analysis showed that students' topics can be determined by looking at the activities they

are engaged in. Log files provided a clear way to determine students' topics which are more difficult to determine when observing students. Therefore, for empirical reasons, this thesis looks at the *practices* that students pursue across *space* (and therefore *time*) instead of looking for topics, which might not be obvious. This improves the way learning is classified. This criterion also shows a relationship between space, time and engagement with devices which also changes as a result of students' movement across space. These are also the factors that control the first, second and fourth criteria of Sharples et al.'s (2007c) framework.

Second, personal learning projects. What is a personal learning project? How can it be determined when observing students or examining their log files since it is not viewable empirically? The log files analysis showed that personal learning projects can be determined as patterns of students' activities over time. Therefore, students' personal learning projects can be determined by looking at their activities over time. But what is the difference between students' personal learning projects and other learning projects? All students' learning projects can be considered 'personal' learning projects, even their formal education, since it is a project they have chosen to engage in.

The discussion showed that the third criterion needs to be reformed considering:

1. Students' activities instead of topics as they are viewable and can be easily tracked to determine the different personal learning projects that students are engaged in.
2. Personal learning projects can be inferred as patterns of students' activities over time.
3. Remove 'instead of following a single curriculum', as students' formal learning is a personal learning project.

The discussion also showed that a case needs to satisfy the first, second, third and fourth criteria for students' learning to be considered mobile.

4. Learners move in and out of engagement with technology

Sharples et al. (2007c) argue that students should move in and out of engagement with technology for their learning to be considered mobile. What if they used conventional devices instead of technology? Can their learning be considered mobile? The pilot study showed that students' learning can be mobile even if they use conventional devices (e.g. handouts) to aid their learning. For example, in traditional learning, students usually use conventional devices (e.g. handouts) to aid their learning and still their learning can be considered mobile as it satisfies all of the mobile learning properties. This means that for students' learning to be considered mobile it is not necessary to use any type of technology as long as there is some

sort of learning resources that can be used to aid students' learning across context which distinguishes mobile learning from any other form of learning.

This criterion also raises the issue of deciding when a student is considered moving in and out of engagement with devices. Should the time between students' engagement in and out be long or short? For example, a student may be looking at the computer monitor, then looking at a handout, and then looking at the monitor again in just a few minutes. Can this be considered as moving in and out of engagement with devices? In this case the student is already static, even if he/she is moving in and out of engagement with the devices. And since one of the requirements of mobile learning is that learners learn across space and time, therefore, moving in and out of engagement with devices should only be considered when it spans space, time, and engagement with multiple activities as students continuously use their devices to refer backward and forward to learning resources. These are also the factors that control the first, second and third of the mobile learning properties discussed by Sharples et al.'s (2007c).

The discussion of this criterion shows that the fourth criterion needs to be reformulated to consider learning resources available on conventional or portable devices instead of technology as mobile learning was shown to occur even when students use conventional devices. It also shows that the other three criteria need to be satisfied for students' learning to be considered mobile.

Summary

The discussion of Sharples et al.'s (2007c) mobile learning properties showed that these properties need to be reformulated to classify mobile and static learning. The discussion also supported the fact that these properties are interrelated with each other. Therefore, for students' learning to be considered mobile, first, a case should satisfy the first criterion which is taking *learning resources* gained in one context and applying or developing them across different *contexts*. The discussion showed that there is a relationship between space and time as when students are learning across space they will inevitably be learning across time too. Similarly, when students are learning across time by revisiting learning resources they should have been moving across space as mobile learning occurs as a result of students' movement across space. Therefore, when a case satisfies the first criterion it will inevitably satisfy the second criterion and when a case satisfies the second criterion it should satisfy the first criterion too. The discussion also revealed that the first and second criteria can be joined to consider students learning across context (physical and social) when they revisit learning resources gained in another context. This also leads to students moving from activity to

another by managing a range of personal learning projects which can be determined by looking at students' *activities* over time. And, students will automatically be moving in and out of engagement with the used devices *(portable or conventional)* as a consequence of their movement across different physical locations.

The above discussion showed that for students' learning to be considered mobile their learning should support all of Sharples et al.'s (2007c) criteria. This can be ensured by satisfying the altered first criteria as it guarantees that all the other criteria will be automatically satisfied. The table below contrasts Sharples et al.'s (2007c) mobile learning properties and the modifications proposed above which need to be introduced to better implement these properties.

Table 5-3 Sharples et al.'s (2007c) mobile learning properties vs the proposed modifications

Sharples et al.'s mobile learning criteria	Proposed modifications
Learn across space as they take ideas and learning resources gained in one location and apply or develop them in another	Using *learning resources* to aid students' learning. Consider *context* instead of location to account for both the physical and social settings of learning activities.
Learn across time by revisiting knowledge gained earlier in a different context which then provides a framework for a lifetime of learning	Using *learning resources* to aid students' learning. Consider *context* to be the combination of the physical as well as social setting of learning activities. 'time' as long as a student is changing his/her physical location and move from activity to another by managing a range of personal learning projects
Move from topic to topic by managing a range of personal learning projects instead of following a single curriculum	Consider students *activities* instead of topics as they are more obvious empirically. Personal learning projects can be inferred as patterns of activities over time. Remove 'instead of following a single curriculum' considering students' formal education a personal learning project.
Move in and out of engagement with technology	Consider learning resources available on a variety of portable and conventional devices instead of just technology Students' engagement in and out of devices should span space, time and engagement with multiple activities

Therefore, Sharples et al.'s (2007c) mobile learning properties can be reformed to consider students' learning mobile when they revisit *learning resources* and apply or develop them across different *contexts* (physical and social) by managing a range of *activities* that

cumulatively aid their personal learning projects and consequently change their engagement with the used *devices*. Students' learning will be considered static when a case does not satisfy all these criteria.

For subsequent studies, the reformation of the mobile learning properties will be used to classify learning as mobile or static. In addition, students' mobile learning can be further explored by considering students' utilisation of portable devices in informal settings (e.g. library, home, etc). This can be studied through students' interviews and observing them in different informal settings. The interviews data can be validated by looking for evidence in the observations, students' outcome (coursework, assignments, etc) and students' log files to check whether they referred back to learning resources gained earlier in different contexts and to determine the type of technology (if any) they used to accomplish these outcomes.

5.5.3 Discussion of the research questions

The pilot study revealed some answers to the research questions. It also revealed the importance of studying some issues that were not studied in the pilot study.

Questions 1:

What is mobile learning?

The study helped with understanding mobile learning and the factors that define the concept. It showed that context is an important factor for studying mobile learning considering it as the combination of both the physical and social settings of learning activities. The study also showed that mobile learning can be studied by investigating students' learning activities that take place in different contexts.

Question 2:

How do students in HE utilise portable technologies in formal and informal settings?

Students in the study used three types of portable devices: handouts, mobile phones and laptops in both settings.

First, handouts. The pilot study did not aim at studying students' utilisation of handouts. But, it turned out that they were used to aid students' mobile learning more than any other portable technologies. This shows that students in this study still depend on conventional devices to aid their learning although they have portable devices. This may be caused by the influence of context (including the instructor) on the type of device that students use to facilitate their learning activities. This raises the issue of studying why students still use conventional devices to aid their learning although they have portable devices. This can be done through

students' interviews and investigating the impact of instructors' technology utilisation on students' technology utilisation through observations.

Second, mobile phones. They were used inside the classroom not to aid students' learning but to subvert formal learning. They were mainly used for communication purposes where students used them to communicate with others inside and outside the classroom.

Third, laptops. Although some students had their laptops during classes, they were only occasionally used to carry out activities in formal settings. Laptops were mainly used in formal settings to subvert formal learning or work on other courses' materials. The devices were mostly used outside the classroom to carry out learning activities and as personal organisers.

Focus Question 1:

How does the use of portable technologies differ when they are supplied as part of a study, rather than when they are used by students as part of their routine study practices?

As illustrated in the Methodology chapter, this question should be answered by comparing the study findings with the findings in the literature. The pilot study did not provide any strong answers for this question. The study revealed that some issues need to be studied to be able to answer this question. For example, it was shown that students use more than one type of portable devices (portable and conventional) to aid their learning. These devices were used to serve the same purposes. In addition, the log files and questionnaire responses analysis showed that when portable devices are used over a long period of time, they become more integrated in a student's life and students depend on them more for their learning and personal activities. It is important for subsequent studies to investigate if the same findings are applicable more widely.

Focus Questions 2:

What is the influence of portable technologies on HE students' educational practices?

Both handouts and laptops helped students' to share representations while discussing issues. Laptops provided access to learning materials when needed by students in different contexts. They also aided students' problem solving as they enable students' communication and web searching looking for solutions. Portables not only were used to aid students' learning, they were also used to subvert formal education.

The analysis of the log files showed that laptops enable students to create contexts that the other students could not create such as remotely running a program on a server while being in

a lecture. In addition, they enable students to change the topic they are working on without changing their context such as working on other courses' materials while being in a lecture. Moreover, they enable students to do the things that the students using conventional devices could do and more such as providing students with access to resources (e.g. learning material, online access) and ways to communicate with people.

Question 3:

What is the relationship between context and learning activities?

The study showed that studying student' learning activities that take place in formal and informal settings and mobile learning require understanding the context (physical and social) of learning activities. This is because mobile learning activities take place in different locations which may have different settings that may influence learning activities. In addition, the study showed that the context of learning activities changes by the change in the social or the physical setting of learning activities. The study also showed that portable devices enable students to engage in activities and create contexts that the students using conventional devices could not do or create. This question can be further investigated by looking at students' learning activities that take place in informal settings which was not widely investigated in this study.

Focus Questions 3:

What is the impact of instructors' portables use on students' utilisation of portables?

The pilot study showed that context (including people) influences students' technology utilisation. One factor is instructors' expectation of students' technology utilisation where instructors unconsciously influence students' behaviour and their technology utilisation. For example, when instructors expect students to use one type of technology (e.g. the expectation that students will bring handouts to class to work with), students will automatically be forced to use that technology. The impact of instructors' expectations can be further studied by investigating what technology instructors usually use in the classroom and how they think this technology should be utilised by students.

Another factor that affects students' technology utilisation is their expectation of their instructors' technology utilisation. Students may expect their instructors to be expert in using technologies and any good or bad experience may affect their technology usage. This issue can be further studied through students' questionnaires and interviews.

In addition, this question can be answered by studying students' outcomes such as assignments and coursework and comparing them with instructors' documents to find any influence in structure or layout of documents.

Focus Question 4:

What is the impact of context on students' communication?

The three types of portable devices that students used in the study (handouts, mobile phones and laptops) aided students' communication. Mobile phones and laptops were used for communication purposes in both formal and informal contexts. Students used their mobile phones in formal settings to subvert formal education and communicate with each other inside the class or with others outside the class. The log files analysis showed that the student used his laptop to communicate with others to solve problems or discuss educational matters mostly in informal settings as he did not use his laptop very often in formal settings. Handouts were also used to share representations and facilitate discussions both in formal and informal settings. The log files showed that laptops can also be used to share representation as students use them to share and discuss documents.

The study showed that students' communication through portable devices (old and new) is influenced by the context (physical and social) of learning activities such as the ability of use the devices for communication purposes. This was reflected in the way students used the devices which, in the study, was mostly secretly in formal settings as the instructors discouraged this. Subsequent studies should study students' communication through portable devices in informal settings as this issue was not widely investigated in this study. This also enables studying the similarities and differences in students' communication in different settings.

5.6 Conclusion

This chapter has described the pilot study that was conducted to examine the study methodology and the extent this helps to answer the research questions. The study helped with understanding the devices, not necessarily portable technologies, which students usually use to facilitate their learning in formal and informal settings and how these devices are used to facilitate learning. The study also helped with understanding the concept 'mobile learning' and showed that some modifications need to be presented to one of the used analysis models (Sharples et al.'s (2007c) mobile learning properties) which was used to investigate mobile learning. The study also revealed that some modifications need to be introduced to any subsequent studies for more efficient data collection such as video recording classes to get in-depth details of students' learning activities. In addition, the pilot study helped partially in

answering some of the research questions and revealed the importance of studying some issues that help with fully answering these questions. The next chapter discusses a study that was conducted to implement the proposed modifications in this chapter and seek more answers to the research questions.

Chapter 6

Conceptualising Mobile Learning: A Study of the Use of Laptops in Higher Education

This chapter discusses a study that was conducted to incorporate some of the learning lessons and changes proposed in the previous chapter to the data collection and analysis techniques to help answer the research questions. The changes also help with developing a conceptualisation of mobile learning through using the modified mobile learning properties discussed in the previous chapter. The chapter begins with a summary of the proposed changes and an explanation of which of these were implemented. This is followed by a description of the procedure and methods used to collect and analyse the data. The findings of the study are then used to answer the research questions.

6.1 Changes to the study

This section describes the methodological and analytical changes proposed in the pilot study chapter and the possibility of incorporating them in this study.

6.1.1 Methodological changes

One of the problems encountered in the pilot study was the low response on the questionnaires. It was suggested that administrating the questionnaire by asking students to complete and return them before leaving the class may enhance the questionnaires' response rate. This technique was implemented in this study and indeed the questionnaire response rate did arise.

In addition, it was suggested that the lack of adequate description of the observational data should be overcome by video recording lectures. However, this could not be implemented in the study as a result of restrictions placed by the university where the study was conducted. These are further discussed in Section 6.2.2.

6.1.2 Analytical changes

In the previous chapter, the mobile learning properties proposed in Sharples et al. (2007c) were used to classify learning as mobile or static. However, these properties had some ambiguities which were resolved by modifying them. The modified properties are used to analyse this study's observational data.

6.2 Study setting and sample selection

As discussed in the previous chapter, the pilot study provided information about the devices (old and new) that students usually use to facilitate learning, particularly in settings where portable technologies are not widely used for teaching and learning. The study discussed in this chapter explores students' utilisation of portable technologies (e.g. laptops) to aid their learning activities in settings where the devices are used to facilitate teaching and students' learning. This enables contrasting students' utilisation of conventional devices and portable technologies especially in relation to the setting where these are considered an integral part of students' learning. This also helps build an understanding of the relationship between context and learning activities and the influence of context on the choice of device used.

The study was undertaken in December 2005 in a medical university in Bahrain (in the Middle East) with around 250 students. The university is a subordinate for a university in Ireland, thus it implements the policies and practices of the original university such as the language of instruction (English), teaching strategies and exams. The university also implements a campus wide laptop program, which the university in the pilot study did not. Thus, this study's setting is different than the pilot study's setting in that the students were supplied with portable devices (laptops) and were expected to use these for their daily learning activities such as viewing lecture notes and participating in tutorial sessions (through bulletin boards). In addition, students had accessibility to resources that enabled using the devices in different contexts which the students in the pilot study did not have, such as wireless access to the Internet throughout the university, accessibility to power sockets and the availability of electronic learning resources.

This study focused on students' utilisation of portables in formal settings as studying students in informal settings was not possible because of restrictions placed by the university as a condition of access. In addition, getting the university's agreement to install the system monitoring software on students' laptops proved impractical. Thus, students' utilisation of portables was mainly studied in formal settings through observations of three undergraduate classes.

6.2.1 Formal learning settings

Students' utilisation of portables in formal learning settings was studied through students' questionnaires and observations of undergraduate courses' classes. Access to classes was sought by approaching a number of instructors via e-mail (Appendix B) to ask for their permission to conduct the study in any of their 2nd or 3rd year classes. Three instructors for three different subjects (Anatomy, Pharmacology, and Chemistry) agreed for the study to be conducted in their classes. Students were then approached and asked to take part in the study. They were provided with consent and authorisation forms and an information sheet which included details about the study and listed how they could participate. Students willing to participate were asked to sign and return the consent and authorisation form. They were also asked to complete the questionnaire.

All students in the participating classes had their own laptops which were provided by the university in their first year. They usually used their laptops in formal settings to view lecture slides and take notes. Power sockets were available in close proximity to students in lecture theatres and they had wireless Internet access.

Anatomy and pharmacology courses

The same group of students were observed in two different courses (Anatomy and Pharmacology). The class included 50 students and ran for one or one and a half hours, one or two times a week (based on a timetable).

The lecture theatre had both a data projector and an overhead projector (OHP). In some sessions (Anatomy course) the instructor used both projectors. The lecture theatre also had a white board and a laptop for instructors so they do not need to bring their own laptops to the classes. Instructors usually downloaded the lecture slides from some storage device (e.g. diskettes or USB memory) and projected the lecture presentations for students to view. The lecture presentations were regularly uploaded on the VLE (Virtual Learning Environment) before the lecture for students to download and/or print. Students were required by instructors to have a copy of the lecture presentation whether on laptop or printed. Most students used their laptops to view lecture slides and take notes during classes. In some classes (Anatomy), students were given handouts to be used during the class; the handouts included images that were not available in the lecture's slides. Students varied in the techniques they used to take notes; some used their laptops (PowerPoint notes beneath the discussed slide or word processor) whilst others wrote in their note books or handouts. During lectures, students would listen, follow the instructor's illustration by looking at the lecture slides (printed out or using their laptops) and write down notes.

Chemistry Course

The chemistry class was a tutorial class where the instructor was solving previously given exercises with students. The class included 15 students. The class ran for one hour a week. The class was observed only once as it was the last tutorial session in the term.

The lecture theatre was provided with a data projector, an overhead projector, a whiteboard, and a laptop. The instructor used the laptop to project the exercises, exercises' answers, and refer back to previous lecture slides. The instructor also used the whiteboard to ask students to write down the answer to the discussed exercises. The exercise sheets used in this session were provided to students as PDF documents uploaded on the VLE. Students were required to download and solve them before the session. During the tutorial session, few students used their laptops to view the exercises; most had the tutorial sheet printed. In addition, students varied in the technique they used to take notes, some used their laptops to type the answers and others wrote them in their handbooks and handouts (although some had their laptops with them).

6.2.2 Informal learning settings

Students' portables utilisation in informal learning settings was studied through the Pharmacology class (the same students as in the Anatomy class) students' questionnaires responses. Students could not be observed in informal settings because of the restrictions placed by the university and thus questionnaire responses could not be triangulated with data that represents their actual use of the technology. This also hindered comparing students' learning activities that take place in formal and informal settings.

6.3 Data collection

The study data was mainly collected through questionnaires and observations. Table 6-1 provides a summary of the data collected in this study.

Table 6-1 Summary of the data collected in the study

Setting	Number of students	Method	Total gathered data
Anatomy class	50 (the same students in the Pharmacology class)	Questionnaires	31 students
		Observations	All students were observed in 3 (one and half hour) sessions
		Interviews	n/a
Pharmacology class	50 (the same students in the Anatomy class)	Questionnaires	31 students
		Observations	All students were observed in one hour session
		Interviews	1 student: Instant messaging software (2 instances – 15 minutes)
Chemistry class	15	Questionnaires	n/a
		Observations	All students were observed in one hour session
		Interviews	n/a

6.3.1 Questionnaires

To enhance students' questionnaires responses, as proposed in the previous chapter, students in the Pharmacology class (which are the same students in the Anatomy class) were asked to complete the questionnaire before leaving the class. Students were also given the choice whether to complete the questionnaire or not. A total of 31 (60%) students completed the questionnaires. The students in the Chemistry class were not asked to complete the questionnaire because they could only be observed in one session. Although the questionnaire would provide a general idea about the group's routine utilisation of portable devices for learning, students' responses could not be followed up nor explored thoroughly through one session observation.

6.3.2 Observations

As discussed earlier, students in this study could not be observed in informal learning settings as a result of restrictions placed by the university. Students were only observed in formal settings inside the classroom. The Anatomy class students were observed in three sessions. The Pharmacology and Chemistry students were observed in only one session per group.

6.3.3 Informal interviews

The restrictions placed by the university prevented approaching the participating students to request more information about issues that were observed. However, one of the participating students volunteered to be contacted through instant messaging software to provide more information about the chemistry tutorial session. The student was interviewed on two occasions.

6.4 Data Analysis

This section describes the analysis of the research data that was gathered through questionnaires and observations. The data collected through interviews was not formally analysed, but it was used to clarify some of the issues observed in the Chemistry class.

6.4.1 Questionnaire analysis

Unlike the pilot study's questionnaire, the questionnaire in this study was considered as a survey that provided information about the samples' utilisation of portables because the response to the questionnaire represented 60% of the sample. This enabled representing the data as charts to demonstrate the sample's utilisation of portables in formal and informal settings.

The questionnaire consisted of both closed and open-ended questions. All of the responses to the questionnaire were entered into a computer-based statistical analysis package (Microsoft Excel). As the study is exploratory, the aim was to describe and represent patterns of use (descriptive statistics) rather than test hypotheses (analytical statistics). The responses to the closed questions were allocated codes and entered. Answers to these questions were presented as diagrams that show the percentages of students belonging to each of the question's responses for the variable in question. For example, the questionnaire included a question about the purpose of using portables inside the classroom. Students were provided with a set of answers from which they can choose as many as apply to them. These answers were used as categories in the charts (shown in Section 6.5.1) to show the percentages of students belonging to each category.

In addition, the open-ended questions invited in-depth data about some of the research questions. The responses to these questions were entered to the computer-based statistical package as they are. The responses were then coded by combining the detailed information contained in the responses into a limited number of categories, which are similar in content. This allowed simple description of the data. For example, the questionnaire consists of a question about the factors that encourage students to use their portables inside the classroom. A number of categories were formed based on students' responses as follows: lecture settings, device properties, and personal issues.

6.4.2 Observational data analysis

As suggested in the pilot study chapter, the modifications introduced to the mobile learning properties discussed in Sharples et al. (2007c) were used to analyse the observational data in this study. The observational data were analysed similarly to the pilot study's observational

data, based on the type of device (whether portable or conventional) and the type of learning that the device assists (whether mobile or static). This helped with classifying the study cases to one of the following categories which also form the sampling frame for including cases in the Findings section:

- Portable device – mobile learning
- Portable device – static learning
- Conventional device – mobile learning
- Conventional device – static learning

All observational data cases were analysed and sampled, and then a subset that illustrate the types of use observed was chosen for inclusion here. The observational data were also analysed using activity theory to understand students' activities, identify any contradictions that might occur in the activity system, their impact on the system and how students resolved them.

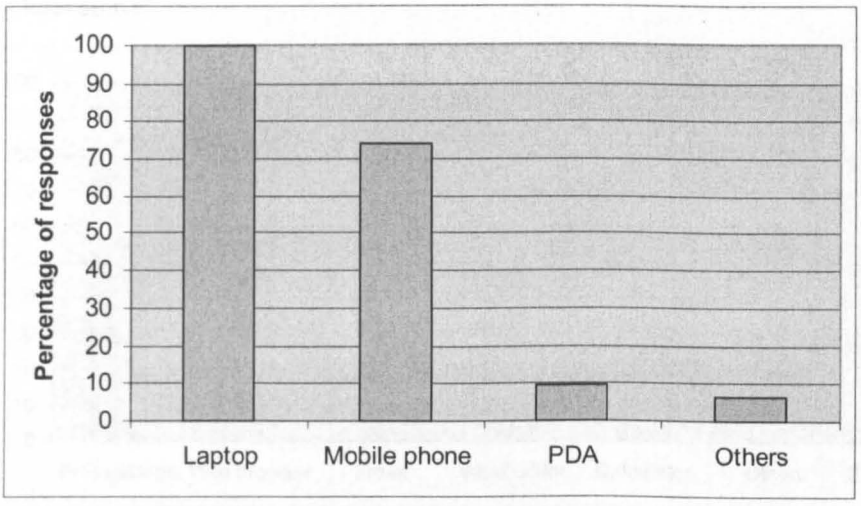
6.5 Findings

This section describes the findings of students' questionnaires and the observational data.

6.5.1 Questionnaires findings

This subsection discusses the questionnaire findings by illustrating what it revealed about each of the issues of concern to the research. Some of the questionnaire findings were supported with data collected through observations of students. But first, here is an overview of the percentages of portable technologies usage by the participants, shown in Figure 6-1. The questionnaire showed that all students used their laptops (100%), most of them used mobile phones (74%) and some used other portable technologies such as PDAs, MP3 players and electronic dictionaries (6%). The questionnaire also showed that students use laptops and mobile phones more than using other portable devices. This may be due to the availability of these devices, specifically laptops which are supplied by the university and which students are expected to use for their daily learning activities.

Figure 6-1 The percentages of portables usage by students



Portables' utilisation in formal settings

The questionnaires showed that the participants use their portables in formal settings on a daily basis. The students reported (shown in Figure 6-2) that they mainly use presentation applications, web browsers, email systems, instant messaging (IM) software and e-dictionaries in formal settings. The participants occasionally use word processors and calculators but rarely use spreadsheets. Factors such as the nature of the course and the setting of the lecture may affect the applications that students use in formal settings.

Students clarified that they use their laptops inside the classroom to view lecture notes and read course materials. The observations support this. In addition, students stated that they use their laptops to navigate the Internet which was also observed as students were searching the Internet for material related to the lecture, reading newspapers and viewing other websites of interest. The questionnaire showed that students use their laptops inside the classroom to read/write emails, chat using instant messaging software, search for the meaning of words using e–dictionaries, access the virtual learning environment, listen to music, and play games. The observations showed that students used their laptops to accomplish all these tasks except listening to music and playing games. Figure 6-3 shows that students typically use their laptops inside the classroom to view lecture slides, access websites, take notes, read/write emails and chat with colleagues, and rarely to play games or use spreadsheets.

Figure 6-2 Students' responses to the question: 'What are the applications that you use in the classroom?'

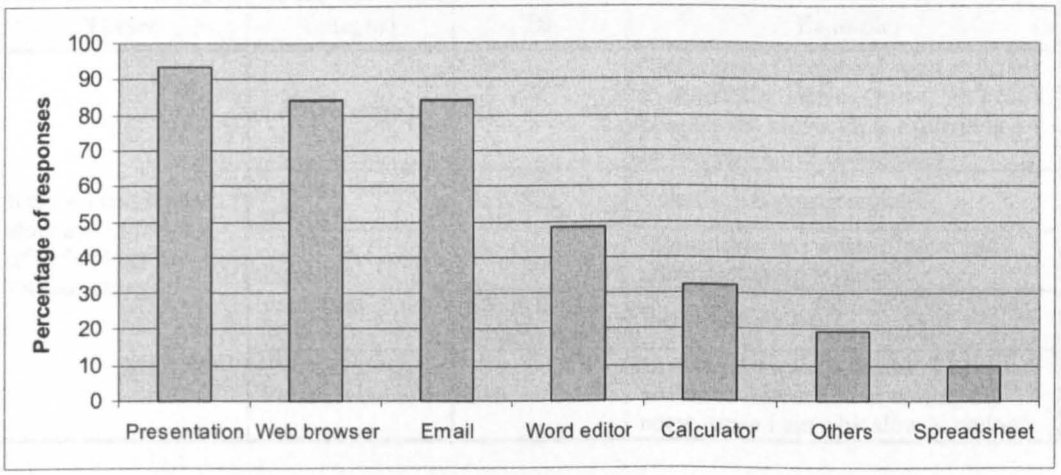
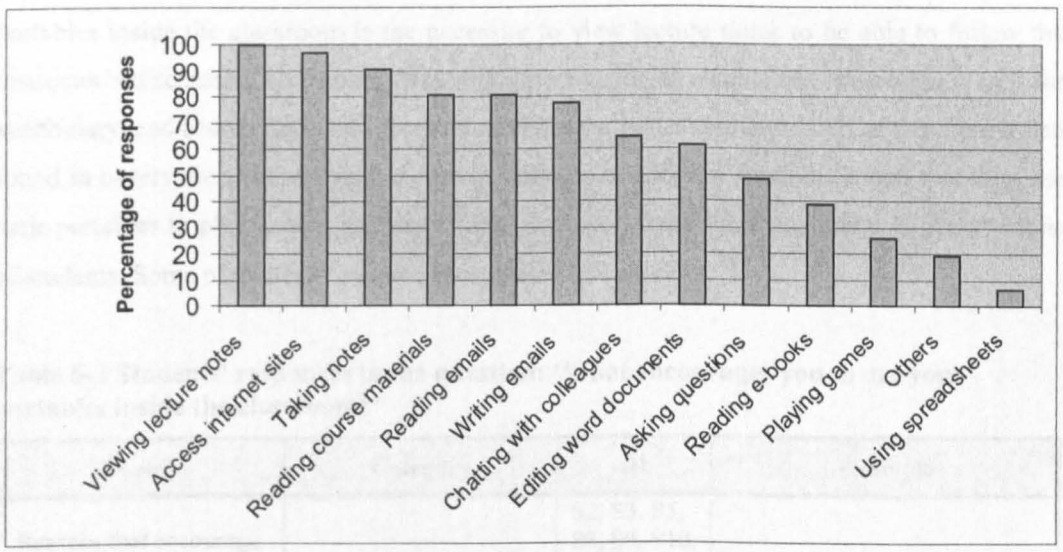


Figure 6-3 Students' responses to the question: 'What are the purposes of using your laptops inside the classroom?'



The relationship between context and learning activities was investigated by asking students to list the reasons that hinder their utilisation of portable technologies in formal settings. Students' responses for this question were grouped into four categories: lecture settings, lecture theatre settings, device properties, and personal issues. Students clarified that the use of portables in formal settings is limited because of portables' short battery life and insufficient power sockets. Some students clarified that laptops distract their attention from the lecture as they can easily be used to subvert formal education without being noticed. In addition, note taking using portables is a time consuming process especially for those who are slow in typing. Some of students' responses are listed in Table 6-2.

Table 6-2 Students ' responses to the question: 'What stops you from using your portables more inside the classroom?'

Theme	Category	ID	Example
Reasons that hinder students' utilisation of technology in formal settings	Lecture settings	S5	'Sometimes I feel that I want to listen to something such as Quran, but I can't because the instructor is explaining a lecture and I will disturb him'
	Lecture theatre settings	S12, S28	'Insufficient power sockets'
	Device properties	S6	'Sometimes it is waste of time and attention during lectures'
		S1, S10, S12, S17, S18, S28	'Short battery life'
	Personal issues	S16	'As the instructor talks fast, I become unable to follow him in writing my notes, since I am a bit slow in typing'

Students were also asked to list the reasons that encourage them to use their portables in formal settings. Their responses were grouped into three categories: lecture settings, device properties, and personal issues. Students stated that what encourages them to use their portables inside the classroom is the necessity to view lecture notes to be able to follow the instructor's discussion, take notes, chat with others inside or outside the classroom, search for vocabulary, and search for more information about the issues discussed. All of these were also found in observations of students in formal settings. In addition, students stated that they use their portables to play games and share files. However, these were not found in observations of students. Some of students' responses are listed in Table 6-3.

Table 6-3 Students' responses to the question: 'What encourages you to use your portables inside the classroom?'

Theme	Category		ID	Example
Reasons that encourage students' utilisation of technology in formal settings	Lecture settings		S2, S3, S5, S8, S9, S10, S11, S12, S18, S21, S23, S24, S25, S31	'It is a must for viewing lecture presentations'
			S3, S21, S28	'It is making it easier for us to follow the lecture'
			S5, S6, S9, S10, S15, S16, S18, S20, S28, S31	'Laptops are needed daily for taking notes'
	Device properties	Accessibility	S3, S6, S7, S10, S15, S20, S21, S23, S30	'Fast way in searching, easy way to find the words' meanings, save time file sharing'

		Portability/ mobility	S16	'Laptop let me study and revise anywhere and any time I like'
		Communication	S6	'Can chat and do other things if the lecture is boring'
			S31	'Using email to contact colleagues and lecturers'
	Personal issues		S13, S14, S17	'Save time and effort' 'Makes studying easier' 'More comfortable than using traditional books'

Portables' utilisation in informal settings

Students' responses to the questions exploring their portables usage in informal settings could not be validated with observational data as students could not be observed in informal settings in this study due to some restrictions placed by the university.

The questionnaire showed that students used their portables in informal settings on a daily basis. Figure 6-4 shows that students typically use web browsers, email systems, presentations, and word editors outside the classroom. The figure also shows that spreadsheets are used the least. Students also reported that they use their portables in informal settings to view video files, listen to music, view pictures, use instant messaging software, and use e-dictionaries. These were listed under 'Others' item of the question. Comparing students' responses to this question and that of using portables in formal settings shows that, although students use their portables in informal settings to carry out activities that they could not carry out in formal settings, their utilisation of the devices is similar in both settings.

The students clarified that they typically use their laptops in informal settings to view lecture notes, access web sites, read/write emails, chat with colleagues, read course materials, edit word documents, ask questions, read e-books, and take notes. The questionnaire showed that they rarely use spreadsheets, e-dictionaries, watch movies and play games in these settings. This is shown in Figure 6-5.

Figure 6-4 Students' responses to the question: 'What are the applications that you use outside the classroom?'

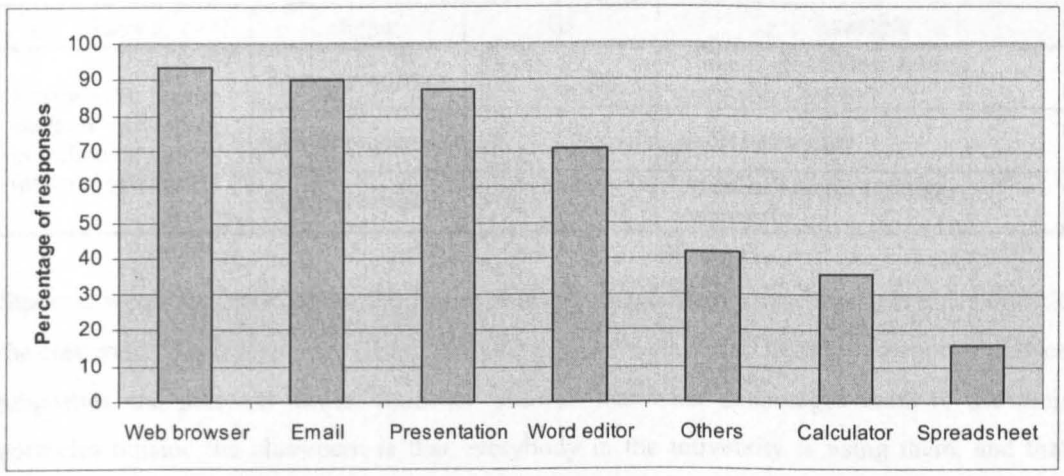
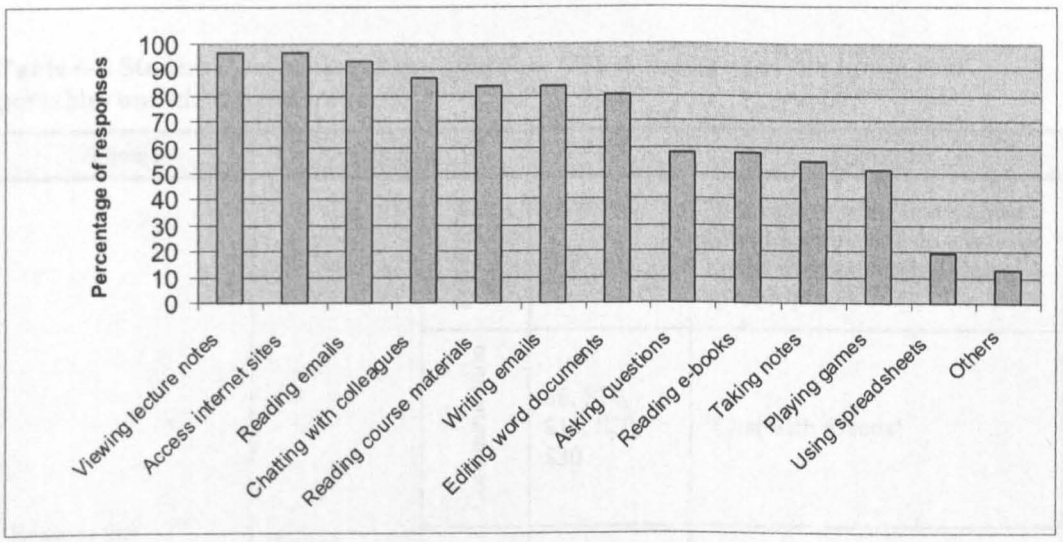


Figure 6-5 Students' responses to the question: 'What are the purposes of using your laptop outside the classroom?'



To study the relationship between context and learning activities the students were asked to list the reasons that prevented them from using their laptops in informal settings. Their responses were classified into three categories: setting properties, device properties, and personal issues. Students reported that limited laptops' battery life hinders their utilisation of portables in informal settings. In addition, they stated that the limited availability of Internet connections at home and wireless network in other places hinders their portables usage in these settings. This shows that there is a link between students' utilisation of portables and the availability of Internet connections. Some students' responses are listed in Table 6-4.

Table 6-4 Students' responses to the question: 'What stops you from using your portables more outside the classroom?'

Theme	Category	ID	Example
Reasons that hinder students' utilisation of technology in informal settings	Setting properties	S3, S8, S9, S23, S24, S30	'There is no wireless access everywhere we go'
	Device properties	S9	'Short battery life'
	Personal issues	S18	'At home I prefer desktop computer'

Students were also asked about the factors that encourage them to use their portables outside the classroom. Their responses (listed in Table 6-5) were classified into two categories: device properties and personal issues. Students' showed that what encourages them to use their portables outside the classroom is that everybody in the university is using them, and that portables provide them with help in their studies and access to their lecture notes and each other. They also stated that the mobility of portables encourages them to study whenever and wherever they like.

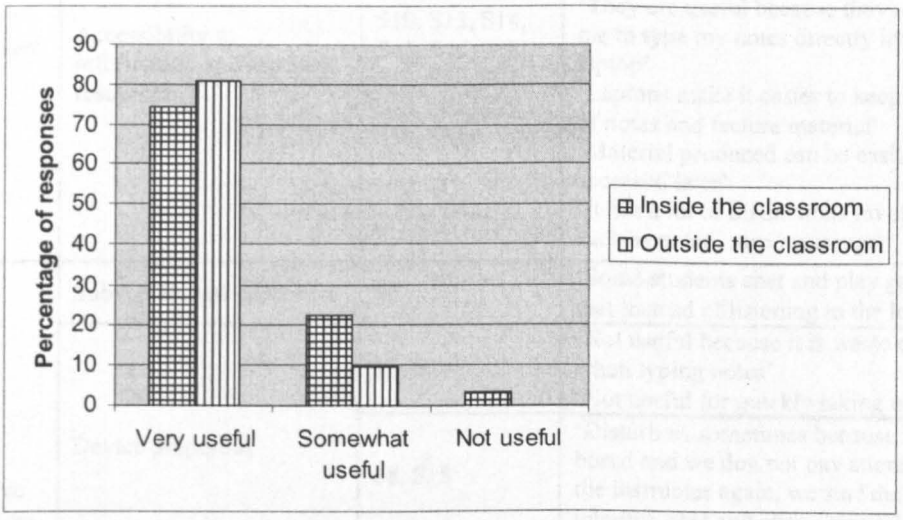
Table 6-5 Students' responses to the question: 'What encourages you to use your portables outside the classroom?'

Theme	Category		ID	Example
Reasons that encourage students' utilisation of technology in informal settings	Device properties	Portability/ mobility	S16	'It is easy to transfer anywhere you like with it and do whatever I want without sticking with a specific place'
		Communication	S6, S10, S12, S20, S30	'Chat with friends'
		Accessibility	S3, S8, S11, S15, S17, S18, S20, S21, S23	'It helps me in my studying and easier to access my university schedule and lectures' 'Most my lectures and notes are saved in it' 'To search for information that I did not understand in the class and could not find a book'
		Entertainment	S13, S20, S23	'Entertainment purposes'
	Personal issues		S2	'Everybody use them'

The influence of portable technologies on students' practices

The questionnaire revealed that students find portables useful both inside (74%) and outside (80%) the classroom. Figure 6-6 shows the distribution of students' responses to the questions regarding the usefulness of portables in both formal and informal settings.

Figure 6-6 Students' responses to the questions regarding the usefulness of portables in formal and informal settings



Formal settings

Students clarified that they believe that portables are useful for class activities because they can be used to view lecture slides as the instructors illustrates, write notes, refer back to previous lecture slides and notes, share files and access vocabulary translation using e-dictionaries, information and media that provide rich description of discussed issues. Students also clarified that their portables are useful because they provide easy access to produced material and ease tracking notes and lecture material. This issue can be further explored in subsequent studies through log files to determine how students keep track of their notes and lecture material.

However, some students stated that instead of listening to the instructor's illustration they get busy chatting and browsing the internet. This shows that portables can be easily used to subvert formal education. They also reported that the applications that they use during classes are limited because their concentration is mainly on viewing lecture slides and taking notes. In addition, they stated that using laptops to type notes is a time consuming process and this motivates them to use conventional devices (e.g. hand books) to write notes. Short battery life also limits their utilisation of their portables in formal settings. Some of students' responses and the categorisation are listed in Table 6-6.

Table 6-6 Students' responses to the question regarding the usefulness of portable technologies in formal learning settings

Theme	Category	ID	Example
Positive influences	Enable communication	S8, S31	'Communicate with our classmates without disturbing others'
	Accessibility to information and learning resources	S1, S2, S6, S9, S10, S13, S14, S15, S16, S18, S19, S20, S21, S25, S26, S29, S30, S31	'We can view the lectures and write notes' 'Easy access to information' 'Useful for taking notes, file sharing' 'They are useful because they allow me to type my notes directly into my laptop' 'Laptops make it easier to keep track of notes and lecture material' 'Material produced can be easily accessed later' 'It has a lot of distinctions involved such as email, msn messenger'
Negative influences	Subvert formal education	S3	'Some students chat and play games that instead of listening to the lecture'
	Device properties	S6, S24	'Not useful because it is waste of time when typing notes' 'Not useful for quickly taking notes'
		S8, S18	'Disturb us sometimes because we get bored and we don not pay attention to the instructor again, we surf the internet, chat and check emails'
		S18	'Battery run out'
	Use related	S11 S5	'The lecturers will apply less effort in explaining the lecture when the notes are in our laptops' 'They are useful but the problem is that the applications used in-class are limited'

Informal settings

Students clarified that what makes portables useful in informal settings is that they allow students to engage in learning activities whenever and wherever they are. Students clarified that they use their portables in informal settings to study course materials, provide easy access to information through the Internet which is more time consuming when searching in printed books, provide a means of communication and entertainment (e.g. listening to music and watching movies), eliminate the need to carry heavy books and printed lecture notes, help in working on assignments and projects, and can be used anywhere and at anytime. Students also reported that carrying out learning activities in informal settings is affected by the slow Internet connection in these settings. This limits students' ability to use their portable devices to engage in learning activities. Table 6-7 lists students' responses based on the categories derived from their responses.

Table 6-7 Students' responses to the question regarding the usefulness of portable technologies in informal learning settings

Theme	Category	ID	Example
Positive influences	Enable communication	S1, S8, S9, S13, S14, S15, S26, S29, S30, S31	'Help in communicating with friends and family'
	Accessibility to information and learning resources	S1, S2, S8, S13, S14, S17, S18, S19, S21, S24, S25, S26, S28, S29, S30, S31	'Easy access to information' 'Easier to view the lecture notes after lectures and manipulate them as I want' 'Provides a wide range of applications' 'Useful in further readings related to my lectures. Useful in doing research and projects'
	Portability /mobility	S10, S16, S20	'No need to carry heavy books, only laptop' 'Transferable and it is available to us anytime and anywhere'
	Entertainment	S9	'They can be used for fun activities such as listening to music and watching movies'
Negative influences	Setting properties	S12	'Slow internet connection'

The impact of context on students' communication

To investigate the impact of context on students' communication, the questionnaire included questions that clarify how and why students use their portable to engage in communication and discussion with others in both formal and informal settings. The questionnaire showed that students use multiple techniques to communicate in formal settings. Most students reported that they communicate face-to-face (93%) with other students inside the classroom on a daily basis. 51% of the students reported that they use their portables inside the classroom to facilitate their communication with others and 90% of these use online communication. Figure 6-7 shows the distribution of students' responses. The figure shows that although students are in a face-to-face environment, they use remote communication techniques for their communication. The observational data also showed that students mainly use their portables to communicate with each other in formal settings. This issue can be further investigated in subsequent studies to investigate the reasons that motivate this way of communication.

Students' reported that they use multiple techniques for their day-to-day communication in informal settings as they use portables (74%), (around 80% of these use online techniques) and communicate face-to-face (74%). This is shown in Figure 6-8. The choice of the used techniques may be affected by the efficiency of that technique and the influence of context (physical and social).

Figure 6-7 Percentage of students' communication methods in formal settings

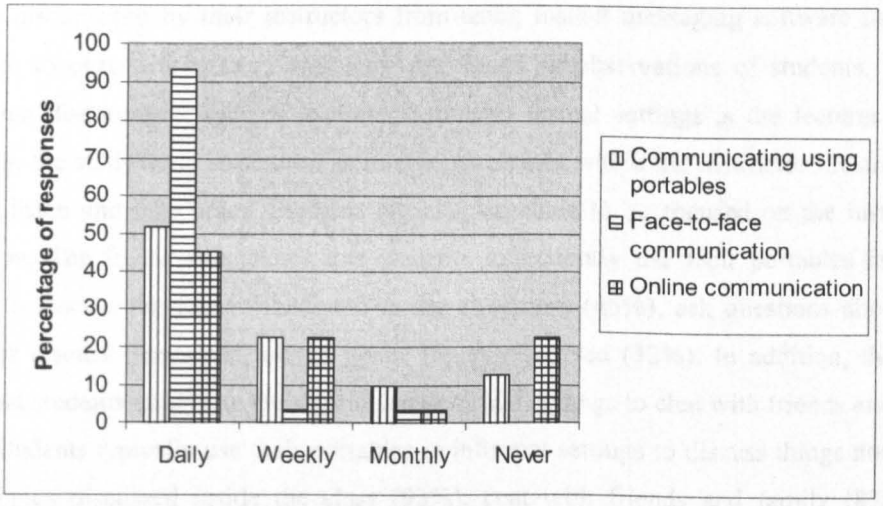
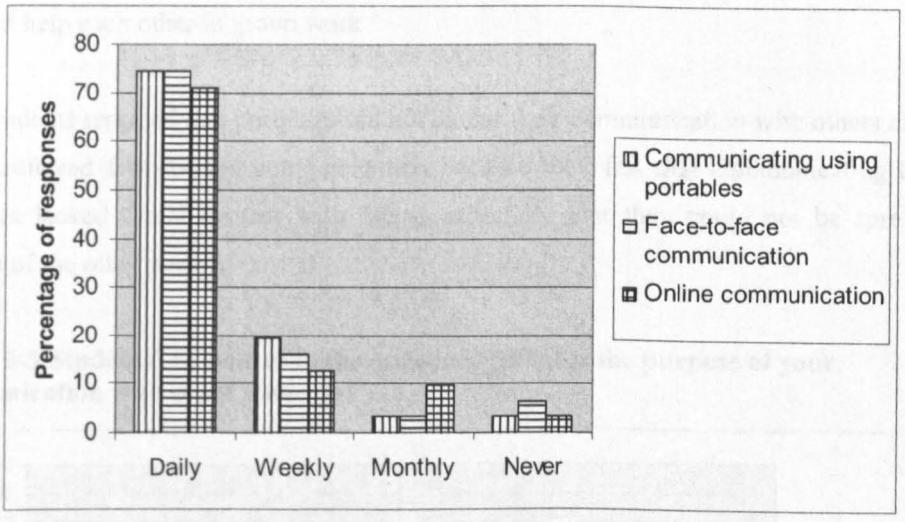


Figure 6-8 The ratios of students' communication methods in informal settings



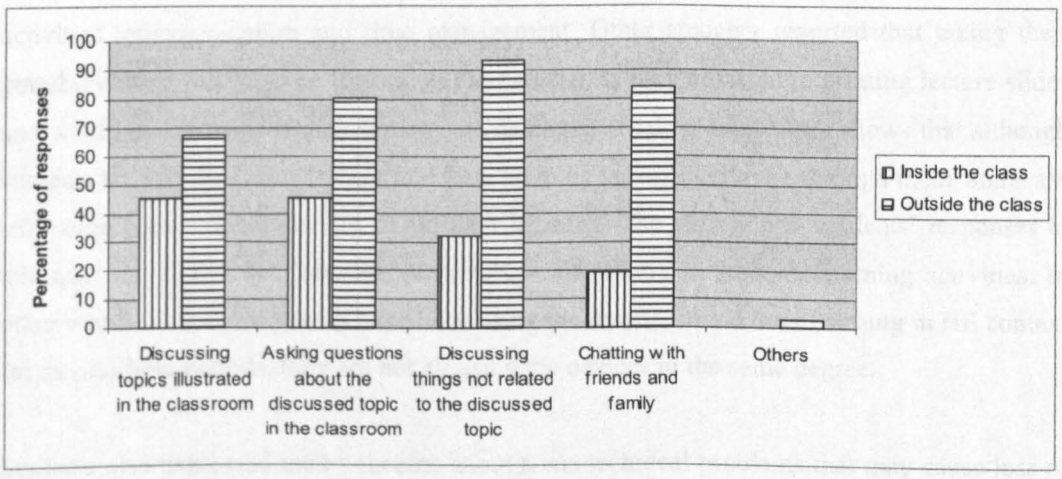
The discussion above shows that although the learning environment enables face-to-face communication as students attend lectures and meet in different informal settings such as the library, students' main communication medium in both formal and informal settings is through their portables. The influence of context on communication in formal and informal settings could not be further investigated in this study because of the lack of observational data of students' activities in informal settings. To investigate this issue, subsequent studies should aim at observing students and looking for communication patterns in both formal and informal settings.

Figure 6-9 shows the distribution of the purposes of using portables for communication purposes in formal and informal settings. The graph shows that students' communication in

informal settings is more than their communication in formal settings. Students expressed that they are discouraged by their instructors from using instant messaging software inside the classroom to chat with others. This was also found in observations of students. Another reason that discourages students' communication in formal settings is the lectures setting. Classes in the study were structured as traditional classes where the instructor illustrates and students listen and take notes. Students are also expected to be focused on the instructor's illustration. The figure also shows that students infrequently use their portables in formal settings to discuss the topics illustrated in the classroom (45%), ask questions about these (45%), or discuss things not related to the topics discussed (32%). In addition, the figure shows that students rarely use their portables in formal settings to chat with friends and family (19%). Students typically use their portables in informal settings to discuss things not related to the topics discussed inside the class (93%), chat with friends and family (83%), ask questions about the topics discussed in formal settings (80%), and discuss the topics illustrated in the classroom (67%). Students also reported that portables enable them to share files and help each other in group work.

Most students reported that portables did not hinder their communication with others although some preferred face-to-face communication because they felt that communicating through portables lacked direct contact with others especially that they could not be sure of the identity of the other person.

Figure 6-9 Students' responses to the question: 'What is the purpose of your communication with other students?'



The impact of instructors' technology utilisation on students' technology utilisation

Most students reported that instructors affect their utilisation of their portables as they are asked by instructors to use their portables to download lecture slides and being up to date

about any changes in exams dates and reports due dates. Students are also expected by their instructors to regularly check their email for any updates regarding the courses. In addition, students clarified that they are usually advised by their instructors to view certain websites and use certain applications to help their learning which also encourages them to search for similar resources. Students also mentioned that they adapt instructors' presentation formats in their presentations. This shows that students are affected by their instructors, who motivate them to copy the style of their presentations. These are also the reasons that encourage students to use their portables to aid their learning.

Most students reported that their instructors' usage of portables has not prevented them from using their portables, although some pointed out that they would like to use their portables to accomplish some of the activities they are asked by instructors not to undertake in formal settings such as using instant messaging software to communicate with others.

General perception of laptops

Students were asked about the impact of taking their portables away from them during their studies. The aim of this question was to investigate to what extent students are dependent on their portables to aid their learning activities and the impact these have on students' life.

Students were divided to two groups. Some students' responses showed that this will have a major impact on their studies as they will not be able to pursue their everyday learning activities, information searching, and will lose communication with others. This shows that some students consider their portables essential for their ability to pursue their learning activities, communication and time management. Other students reported that taking their portables away will have no impact on their studies as they are used to printing lecture slides and would do the same if their laptops are damaged or taken away. This shows that although students are supplied with laptops and their learning is expected to be through them, some are still using conventional devices to aid their learning. The variation in students' responses to this question shows the variation of portables integration in students learning activities. In other words, although students have been using the devices to aid their learning in HE context for similar time periods, they are not all using the devices in the same degree.

Students also expressed their concerns about some technical problems that may cause loss of access to the materials they store on their laptops as these devices are the only source of access to these resources. Others were concerned about health problems that they experienced after using laptops such as sight and back problems. Some students reported that their slow typing ability hindered them from using their laptops more, which makes them use

conventional devices instead. However, others were concerned about using portables for most of their writing which may affect the writing skills that they need for their exams.

6.5.2 Observational data findings

This subsection includes the findings of the observational data. The cases' descriptions are derived from the field notes and are interpreted using the modified version of the mobile learning properties (MLP) discussed in the previous chapter (presented originally by Sharples et al. (2007c)) and activity theory (AT). The cases are classified based on the type of used device and the type of learning that the device assists as in the previous chapter. To recap, the mobile learning properties were reformed to consider students' learning mobile when they revisit *learning resources* and apply or develop them across different *contexts* (physical and social) by managing a range of *activities* that cumulatively aid their personal learning projects and consequently change their engagement with the used *devices*. As mentioned in Chapter 5, the cases discussed here represent small segments of the observational notes that highlight particular instances of learning practices. In addition, the activity theory analysis of the cases also focuses on a small segment of the case represented here to highlight any contradictions in the activity system, their influence on the system and how these are resolved.

Portable device – mobile learning

In this study, exceptional cases that illustrate the innovative usage of portables for learning could not be found. The example here is a typical example as it is similar to the pilot study case where students revisit learning resources gained earlier in a different context except that students in this case are using portable technologies instead of conventional ones.

Case description:

This is a chemistry tutorial session. Students are previously asked to download an exercises sheet from the VLE and solve it before the tutorial session. During the tutorial session the instructor solves the questions which are displayed on the data projector with students. Some students view an electronic copy of the sheet using their laptops, others have them printed.

- All the discussed materials are provided in a document that can be downloaded from the VLE.

...

- Instructor asks students if they had any problems with today's tutorial questions.
- Instructor reads the first question (projected from his laptop) and describes it.
- Instructor asks a student to solve the problem on the whiteboard.
- A student answers the question – instructor re-describes the student's answer and asks the student a question about it and gets an answer.
- Some students are writing down the answers, others are typing them using their laptops, others are doing nothing.
- A student (S1) is using MSN messenger to send a file and chat at the same time.
- Instructor uses his previous lecture notes to describe a diagram that helps in answering the question. Students refer to the lecture notes too.

Interpretation (using MLP):

Focusing on one of the students in the class (S1), the student's learning in this case is mobile as he is referring back to some learning materials (tutorial sheet, lecture slides) that were visited earlier in different physical contexts such as previous lecture theatres and at home as the tutorial session class takes place in a different lecture theatre. The student revisited his lecture slides to look at a diagram that helps answering one of the tutorial questions. The social context of learning activities may also have changed because of changes in the roles and rules of the community engaged in the learning activity. However, the change in the social context of the learning activities cannot be investigated here because of the lack of data about the student's activities in the previous sessions or at home. The student had also managed a range of activities since the last lecture such as solving the tutorial exercises that cumulatively aid his learning. This also changes his engagement with the device used (laptop). However, this means that if the student revisited the learning resources in the same lecture theatre his learning will only be mobile on the assumption that he revisited the learning material sometime between the two lectures in a different space. The same applies to the cases where students' learning is bound to a certain space because of the availability of certain equipments and tools (such as a chemistry laboratory) that need to be used to aid students' learning. These issues will be further discussed in Section 6.6.2.

Interpretation (using AT):

The activity system in this case comprises the student (subject) who is using his laptop (tool) to communicate with others (object) through instant messaging software during a tutorial session. The community includes the student and the other person who is chatting and is governed by a set of rules (read comment/write comment) and division of labour (one reads comment/one writes comment).

A *secondary* contradiction, as classified by Engeström (1987), occurs between rules and the student components of the activity system (shown in Figure 6-10). As argued in Section 3.4.4, secondary contradictions are caused by the emergence of new factors, in this case a new object. The contradiction occurs as a result of the student breaking the rules by chatting with others while being in the class when he is expected by the instructor to use his laptop to listen, look at the exercise sheet (whether on the board, his laptop or printed out), participate in solving the questions, and take notes. The student changed the activity he is engaged in which also changed the rules, community (instructor and students) and division of labour (student/instructor) of the activity system. The student acted like he was following the rule by being in the tutorial session and being engaged with his laptop but he was using it to do other

things. The student resolved the contradiction by using his laptop as a tool that enabled him to achieve his goal without visibly breaking the rules (shown in Figure 6-11).

Figure 6-10 The case's interpretation using activity theory

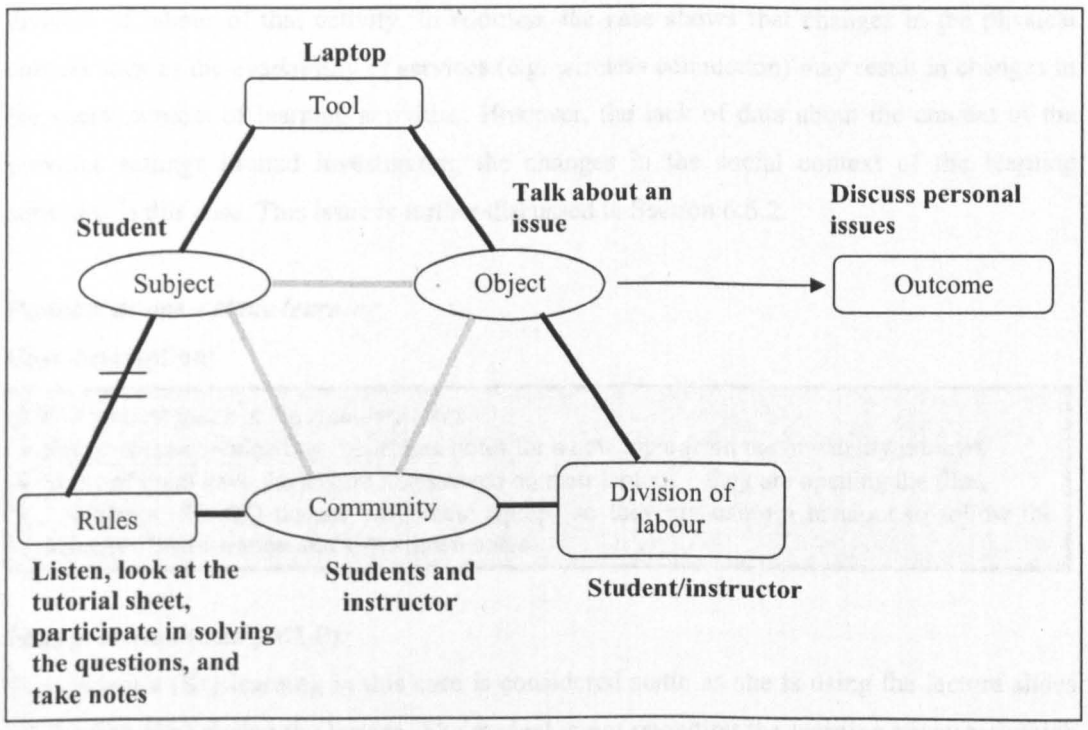
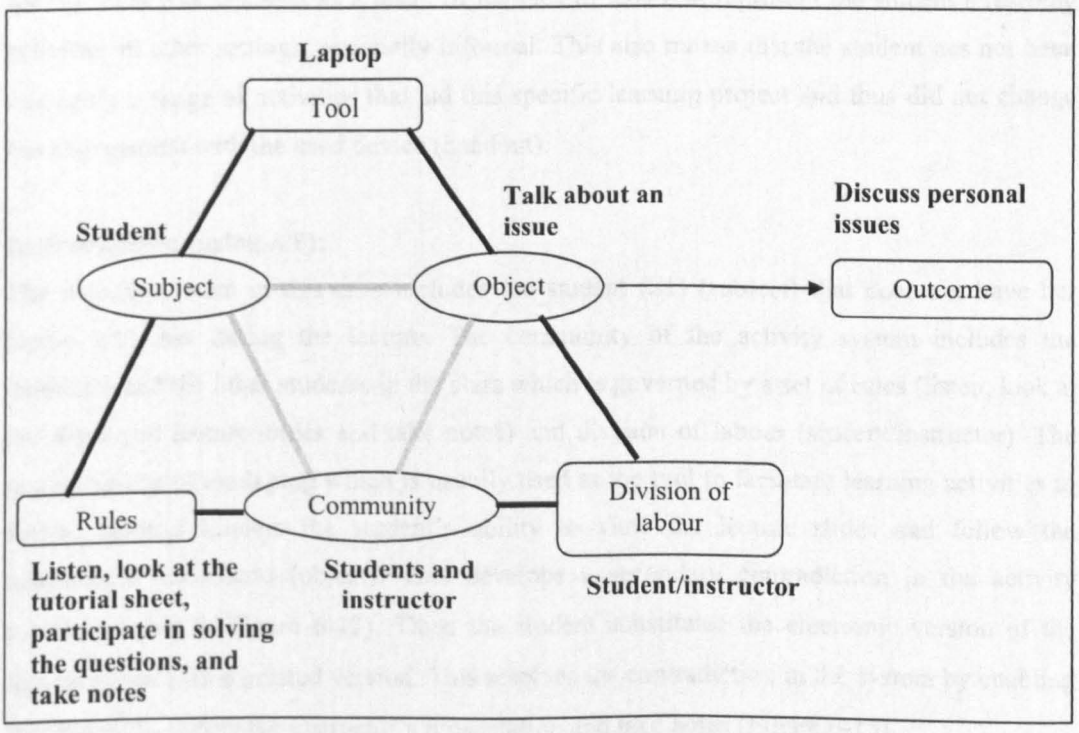


Figure 6-11 The case's interpretation using activity theory (continued)



This case was chosen to be presented here because it illustrates that portable devices not only can be used to aid learning activities in formal settings, they can also be used to subvert formal education and engage in multiple activities without being noticed. The case also shows that changes in the activity pursued may result in changes in the community, rules and division of labour of that activity. In addition, the case shows that changes in the physical context such as the availability of services (e.g. wireless connection) may result in changes in the social context of learning activities. However, the lack of data about the context of the previous settings limited investigating the changes in the social context of the learning activities in this case. This issue is further discussed in Section 6.6.2.

Portable device – static learning

Case description:

The case took place in the Anatomy class
- Students are downloading the lecture notes for a new topic from the university intranet.
- Some of them have the lecture notes saved on their laptops – they are opening the files.
- 2 students (S1, S2) do not have their laptops so they are using a handout to follow the instructor's illustration and write down notes.

Interpretation (using MLP):

The student's (S1) learning in this case is considered static as she is using the lecture slides for the first time during the lecture. The student is not revisiting the learning resources which shows that her utilisation of the learning material did not span different contexts (physical or social). This was assumed as a result of the lack of data that represent the student's learning activities in other settings, especially informal. This also means that the student has not been managing a range of activities that aid this specific learning project and thus did not change her engagement with the used device (handout).

Interpretation (using AT):

The activity system in this case includes the student (S1) (subject) that does not have her laptop with her during the lecture. The community of the activity system includes the instructor and the other students in the class which is governed by a set of rules (listen, look at the displayed lecture slides and take notes) and division of labour (student/instructor). The unavailability of the laptop which is usually used as the tool to facilitate learning activities in formal settings hinders the student's ability to view the lecture slides and follow the instructor's illustration (object). This develops a secondary contradiction in the activity system (shown in Figure 6-12). Thus, the student substitutes the electronic version of the lecture slides with a printed version. This resolves the contradiction in the system by enabling the student to follow the instructor's presentation and take notes (Figure 6-13).

Figure 6-12 The case's interpretation using activity theory

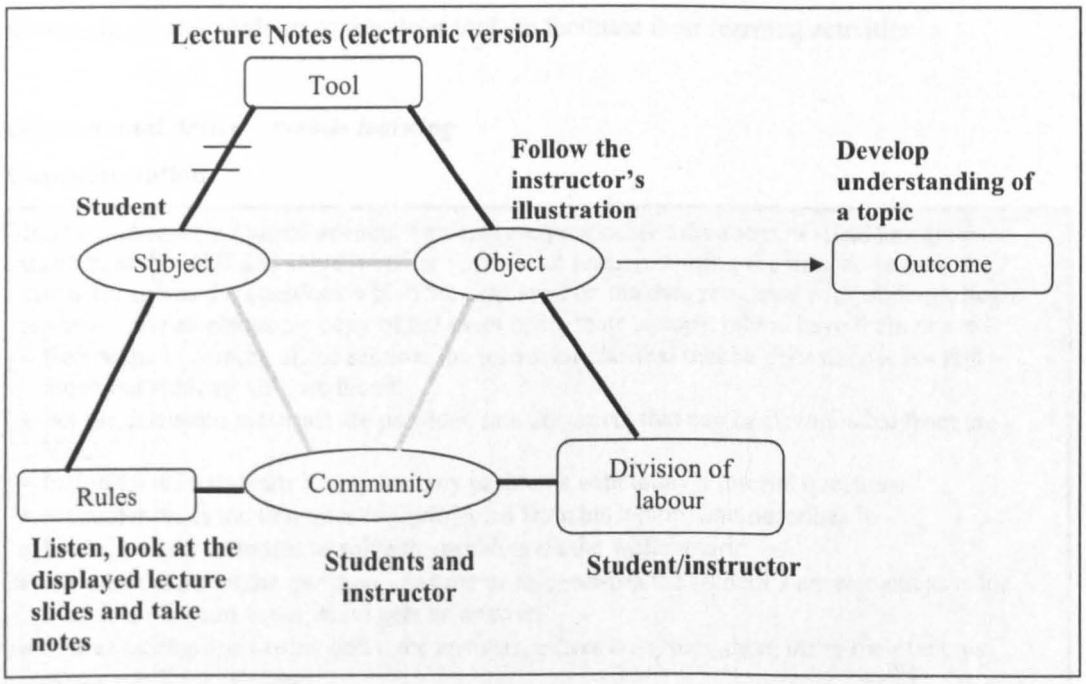
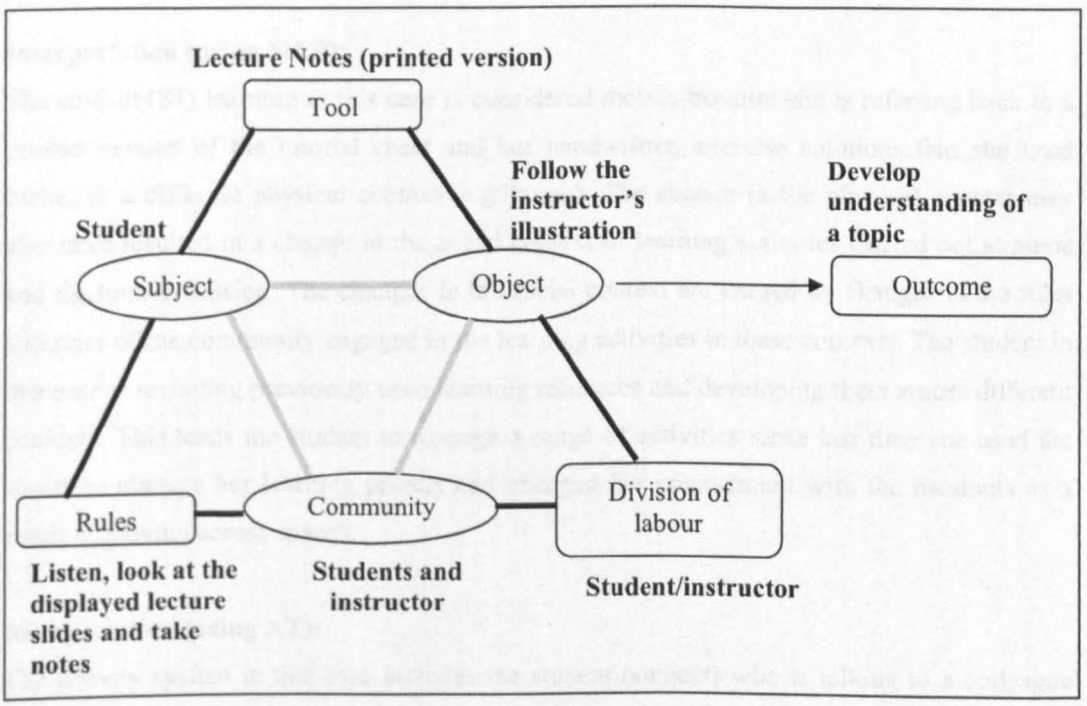


Figure 6-13 The case's interpretation using activity theory (continued)



This case was chosen for discussion to show that although the device used is portable, it can aid static learning. In addition, the case shows that students' learning is probably going to be mobile the next time students refer to the material in a different space. This issue is further

discussed in Section 6.6.2. Moreover, the case illustrates that the unavailability of certain devices motivates students to use other tools to facilitate their learning activities.

Conventional device – mobile learning

Case description:

This is a chemistry tutorial session. Students are previously asked to download an exercises sheet from the VLE and solve it before the tutorial session. During the tutorial session the instructor solves the questions which are displayed on the data projector with students. Some students view an electronic copy of the sheet using their laptops, others have them printed.

- Before the beginning of the session, the instructor clarified that he does not use his laptop much but students still use theirs.
- All the discussed materials are provided in a document that can be downloaded from the VLE.
- Instructor asks students if they had any problems with today's tutorial questions.
- Instructor reads the first question (projected from his laptop) and describes it.
- Instructor asks a student to solve the problem on the whiteboard.
- A student answers the question – instructor re-describes the student's answer and asks the student a question about it and gets an answer.
- Some students are writing down the answers, others are typing them using their laptops, others are doing nothing.
- Two students (S1, S2) are talking about something described in the session and are using their handouts to refer back to points.

Interpretation (using MLP):

The student (S1) learning in this case is considered mobile because she is referring back to a printed version of the tutorial sheet and her handwritten exercise solutions that she used earlier in a different physical context (e.g. home). The change in the physical context may also have resulted in a change in the social context of learning activities carried out at home and the tutorial session. The changes in the social context are caused by changes in the roles and rules of the community engaged in the learning activities in these contexts. The student in this case is revisiting previously used learning resources and developing them across different contexts. This leads the student to manage a range of activities since last time she used the sheets to manage her learning project and changed her engagement with the handouts as a result of moving across spaces.

Interpretation (using AT):

The activity system in this case includes the student (subject) who is talking to a colleague about an issue discussed during the tutorial session (object) using her handout (tool). The community in this case includes the student and her colleague which is governed by a set of rules (look at handout, discuss issues) and division of labour (one discusses issues/other listens). As the student's engagement in discussion was facilitated by her handout, this means that for the student to be able to engage in the discussion she needs to refer to the handout.

The availability of the handout ensures the student's ability to engage in discussions with the colleague and which might not be achieved in case of the unavailability of the handout. Thus, the student's needing the handout develops a contradiction (secondary) in the system (shown in Figure 6-14), which motivates her to look at it to resolve that contradiction (Figure 6-15)

Figure 6-14 The case's interpretation using activity theory

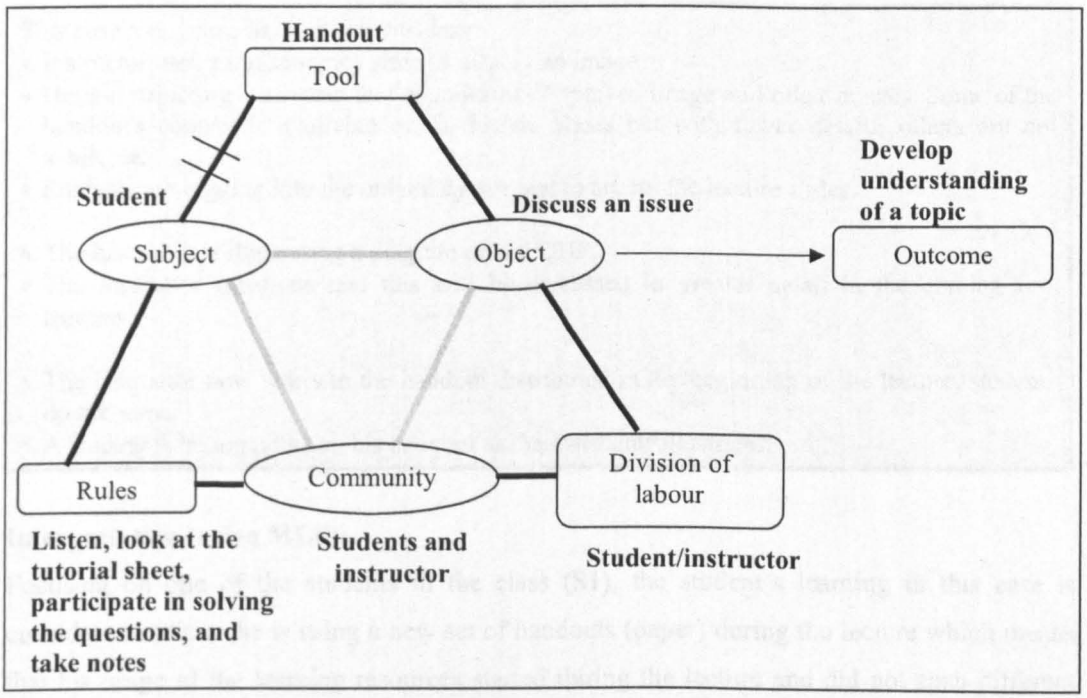
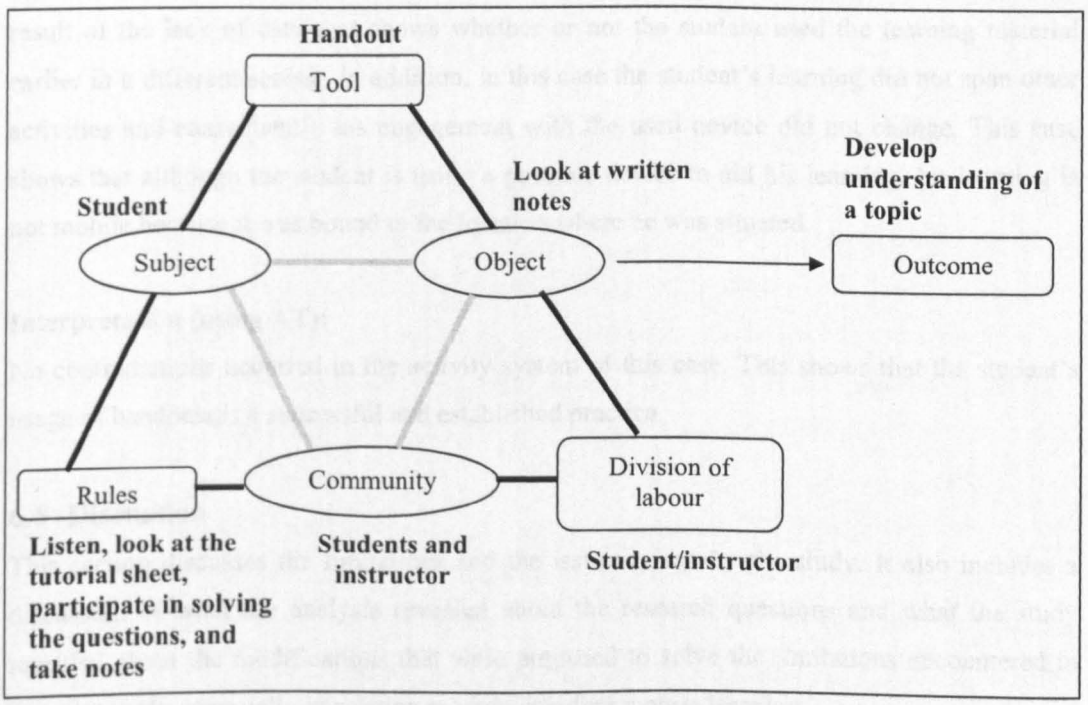


Figure 6-15 The case's interpretation using activity theory (continued)



This is a typical case of using conventional devices to engage in discussions and share representations. The case also shows that mobile learning can be facilitated by conventional devices (e.g. handouts).

Conventional device – static learning

Case description:

This case took place in the Anatomy class

- Instructor uses a transparency slide to display an image.
- He is distributing a handout that contains the displayed image and other images. Some of the handout's content is available in the lecture slides but with fewer details, others are not available.
- Students are logging into the university intranet to access the lecture slides.

...

- The instructor is illustrating a diagram on the OHP.
- The instructor mentions that this will be discussed in greater detail in the coming few lectures.

...

- The instructor now refers to the handout distributed in the beginning of the lecture, students do the same.
- A student is taking notes on his handout as the instructor illustrates.

Interpretation (using MLP):

Focusing on one of the students in the class (S1), the student's learning in this case is considered static as he is using a new set of handouts (paper) during the lecture which means that his usage of the learning resources started during the lecture and did not span different physical contexts which is a requirement of mobile learning. This assumption was made as a result of the lack of data that shows whether or not the student used the learning material earlier in a different setting. In addition, in this case the student's learning did not span other activities and consequently his engagement with the used device did not change. This case shows that although the student is using a portable device to aid his learning, his learning is not mobile because it was bound to the location where he was situated.

Interpretation (using AT):

No contradictions occurred in the activity system of this case. This shows that the student's usage of handouts is a successful and established practice.

6.6 Discussion

This section discusses the limitations and the issues raised by the study. It also includes a discussion of what the analysis revealed about the research questions and what the study revealed about the modifications that were proposed to solve the limitations encountered in the pilot study, especially in relation to understanding mobile learning.

6.6.1 Methodological issues

The study implemented the proposed changes in the pilot study chapter regarding improving students' questionnaire response by asking students to complete them before leaving the class. The response rate has improved as 60% of the questionnaires were returned (in comparison to just 10% in the pilot study).

The study showed that the current usage of portables is successful but not innovative as students used their portables in the same way that students in the pilot study used their handouts. This was shown in the 'portable device – mobile learning' case which is similar to the 'conventional device – mobile learning' case in the pilot study. This indicates that students substitute conventional devices with portable devices. However, this issue could not be investigated more in this study as a result of the inability to study students in informal settings which might have revealed innovative usage of portables outside the classroom. This poses a question about whether innovative usage of portables could not be found due to the limitations of this study or if it is not there to be found. This issue can be further explored in subsequent studies through studying students' utilisation of portable devices in both formal and informal settings and using log files to show whether or not students use their portables differently than using their handouts.

The previous study also proposed video recording students in formal and informal settings to obtain more detailed descriptions of their utilisation of portables in these settings. However, this could not be implemented as a result of the restrictions placed on the study by the university.

The two studies conducted in this thesis so far focused on observing all the students in the classes. This helped with providing a general idea about students' utilisation of portable devices to accomplish their routine learning activities, mainly in formal settings. However, the data lacked detailed description of specific cases' utilisation of the devices in multiple formal and informal settings. This also affected studying mobile learning as a result of the lack of detail about the continuity of students' activities that take place in multiple contexts. Thus, subsequent studies should focus on studying a small number of case studies to collect focused data about students' utilisation of portable devices and the continuity of their practices in multiple contexts. The data also lacked detailed description of the context (physical and social) of learning activities. Having in-depth data about the context of multiple formal and informal settings aids studying the similarities and differences between students' learning activities in these contexts and thus the relationship between context and learning activities. Having in-depth data about the context of learning activities also helps understand

the relationship between the changes in the physical and social contexts. The cases discussed earlier showed that changes in the activities pursued caused changes in the social context (rules and division of labour that governs the community engaged in the learning activity). However, the lack of data about students' learning activities in informal settings limited understanding the relationship between the change of physical and social contexts. Subsequent studies should focus on gathering more data about the context of learning activities in different formal and informal settings to understand the relationship between context and learning activities.

6.6.2 Analytical issues

This section discusses the analytical issues raised as a result of using the revised version of the mobile learning properties discussed in the previous chapter (originally proposed by Sharples et al. (2007c)) to analyse the data in this study, and how that helped with conceptualising mobile learning. The section also reflects on the use of activity theory to analyse the research data in this study and how this helped with developing a conceptualisation of mobile learning.

Reflections on the revised mobile learning properties

The data in this study was analysed using the revised version of Sharples et al.'s (2007c) mobile learning properties. The properties were reformed in the previous chapter to resolve some limitations found when these were used to analyse the research data and study mobile learning. One particular challenge was identifying which of these properties were essential for the definition of mobile learning. Another challenge was identifying a definition for the term '*context*' that helps with studying mobile learning and accounts for the properties of the different learning environments of the learning activities. The mobile learning properties were reformed to consider students' learning to be mobile when they revisit *learning resources* and apply or develop these across different *contexts* (social and physical) by managing a range of *activities* that cumulatively aid their personal learning projects and consequently change their engagement with the used *devices*.

Using the revised properties to analyse this study's data helped with developing the conceptions of mobile learning and context, and understanding the relationship between these. The study also helped with clarifying some analytical issues raised in the previous chapter. The previous chapter raised a question of whether learning is mobile when learning activities continue to take place in the same physical context at different times, such as a series of lectures that usually take place in the same classroom. This study showed that students' learning that continues in the same physical context is considered mobile only when students

revisit their learning resources in different physical context(s) in between. This was based on the fact that what distinguished mobile learning from other types of learning is pursuing learning activities across different physical locations. Empirically, this was tracked through log files collected from students' laptops. It was also argued in the previous study that the social context of learning activities changes each time students are in the classroom. This study showed that the social context of the learning environment in such cases may or may not change. Moreover, the study showed that the social context of learning activities can change as a result of changes in the activity pursued which causes changes in the rules and division of labour of the community engaged in the object of the activity. This issue is further discussed below.

The modifications introduced to the mobile learning properties also helped with classifying learning in the observational data as mobile or static. For example, some cases of static learning were found in this study's observational data which was difficult to find in the pilot study. This was mostly due to the clarifications of the term 'context' that was introduced in the previous chapter which helped with studying and defining mobile learning in this study. However, students' learning in these cases is going to be mobile the next time students revisit their learning resources in a different context, as students invariably were using these resources for the first time which made their learning bound to the space where their learning activities took place.

In conclusion, the studies conducted so far in this thesis have shown that although the mobile learning properties discussed in Sharples et al.'s (2007c) have some limitations, they provide a useful first step towards understanding mobile learning. As discussed in Section 3.1, the aim of using the properties was to help understand mobile learning through studying real-world cases and to provide evidence either to accept the researchers' theorisation of mobile learning or to propose a new conceptualisation. One important theme that was obtained from the properties is the idea that mobile learning occurs when learning activities are mediated by the use of tools across different contexts. The properties also helped with understanding the factors that researchers should focus on in order to understand mobile learning; in particular 'context'. The properties helped with developing an understanding of context that is suitable for investigating mobile learning. Using the properties to study mobile learning in real-world cases also helped with understanding the relationship between context and learning activities. Moreover, using the mobile learning properties and activity theory to study the cases in this study provided an insight into how these can be used to develop a framework to study mobile learning. This is discussed below.

Conceptualising mobile learning

Sharples et al.'s (2007c) mobile learning properties were proposed as part of the researchers' attempt to theorise mobile learning based on the conversational framework (Laurillard, 1993) and activity theory (Engeström, 1987). The researchers developed a framework, discussed in Section 3.4, to study mobile learning. They defined the term as 'the processes of coming to know through conversations across multiple contexts amongst people and personal interactive technologies'. However, this definition implies great focus on students' communicative interactions with peers and technology. The studies conducted in this thesis so far showed that studying learners' activities that are directed towards the same objective across contexts is sufficient for studying mobile learning and differentiating it from static learning. Therefore, this thesis proposes that defining mobile learning requires greater focus on learning practices that are directed towards the same objectives and which take place across multiple contexts, rather than focusing on students' communicative interactions with peers and technology (de-emphasising the communicative interactions). As a result, mobile learning can be conceptualised using activity theory alone and therefore does not require the conversational framework. The conversational framework is mainly helpful when there is a need to understand how students develop understanding of a specific matter through conversation with others or technology, and this is not the objective here.

As part of Sharples et al.'s (2007c) theorisation of mobile learning, the researchers developed a two layered framework for studying mobile learning based on Engeström's expansion of activity theory, discussed in Section 3.4. The framework was proposed to help describe the relationship between people and technology through technological and semiotic layers. The technological layer represents learning as an engagement with technology where tools are used as interactive agents in the process of coming to know and the semiotic layer describes learning as a semiotic system where learners' object-oriented actions are mediated by cultural tools and signs. However, the studies in this research show that this framework is made too complicated because of the introduction of these layers. As argued earlier, the studies showed that using the mobile learning properties to analyse the cases helped with understanding mobile learning through studying learners' activities that take place in multiple contexts. At the same time, using Engeström's (1987) expansion of activity theory to analyse the cases helped with understanding the context of these learning activities and clarified the relationship between context and learning activities. Thus, there seems to be little value in overlaying these separate elements (semiotic and technological layers). In addition, as discussed in Section 3.4, activity theory provides an historical perspective on learning activities. This can be utilised to show the continuity of learners' practices that are directed towards the same

objective in different contexts (physical and social) which aids studying mobile learning in real world cases. The only point that the analysis of the cases using activity theory lacked was the indication of the physical context where learning activities are situated. Location is considered one of the main factors in studying mobile learning and also controls one of the mobile learning properties proposed by Sharples et al. (2007c) (First criterion: *learn across space as they take ideas and learning resources gained in one location and apply or develop them in another*). The representation of location using activity theory is discussed below.

From an activity theoretic perspective, and as argued earlier, mobile learning should not be defined on the basis of the type of device used. Mobile learning can be mediated by any type of physical tools (old or new) or conceptual tools (symbolic or embodied). The study conducted in this chapter showed that mobile learning not only occurs when students use physical tools to facilitate their learning, it also occurs when they use conceptual tools such as language. For example, an instructor discussing and asking students questions about some of the issues that he covered in a lab session while being in a classroom. The tool that the instructor and students used to facilitate their discussion was language and students were using their knowledge to answer and facilitate discussion. Thus, for the definition of mobile learning, both physical and conceptual tools can be used to facilitate learning activities. Based on this, the notion of learning resources, discussed in Section 5.5.2, should include both tangible (e.g. handouts) and intangible (knowledge) resources.

Therefore, the discussion above shows that Engeström's expansion of activity theory is sufficient for studying mobile learning as it has the ability to represent human activities (including the semiotic and the technological layers) that are mediated by tools (physical and conceptual) in relation to the context of learning activities. This eliminates the need for the two layers introduced by Sharples et al.'s (2007c) framework. The researchers also stated that the layers were included as an attempt to introduced related terms that are known to technology designers and educational theorists. This is mainly due to activity theory's Marxist origins where the terminologies used may not be understood by technology designers and thus hinders the communication between them and educational theorists. Activity theory also enables accounting for the communications between peers and technology by treating communication as an example of an activity, which is mediated by the use of tools in relation to the context of these activities. Moreover, using Engeström's (1987) model of activity theory covers the mobile learning properties proposed by Sharples et al. (2007c) as it enables studying learning activities in relation to the space, time and students' engagement with their devices which are the factors that control the properties.

As discussed earlier, activity theory places great emphasis on the relationship between context and humans' activities. Nardi (1996) argues that in activity theory a minimal meaningful context for individual actions is required for basic analysis. In terms of studying mobile learning, studying context helps with understanding and considering the setting (physical and social) of learning activities including the impact of the relations among individuals, artefacts, and social groups within these learning activities. To recap, Cole (1996) and Dourish (2004) defined context as (a) what is constructed through the interactions between learners and technology, or (b) what surrounds the human user of the technology. As discussed in Section 5.5.2, the conception of context in the first definition is misleading when used to define mobile learning by itself because the interactions between the learner and the technology can be constructed and changed even if the learner is physically static. This is also a problem for activity theory. From an activity theory perspective, the context of learning activities can change as a result of a change in the social setting of the learning activity, represented as the community, rules and the division of labour in an activity system. This implies that all learning where the social setting changes is defined as mobile learning. For instance, the community that a student is part of changes when someone comes into the lecture room where the student is located, but arguably, this is not something that should be classified as mobile learning in this thesis. Therefore, the first conception of context alone is not sufficient for supporting the definition of mobile learning.

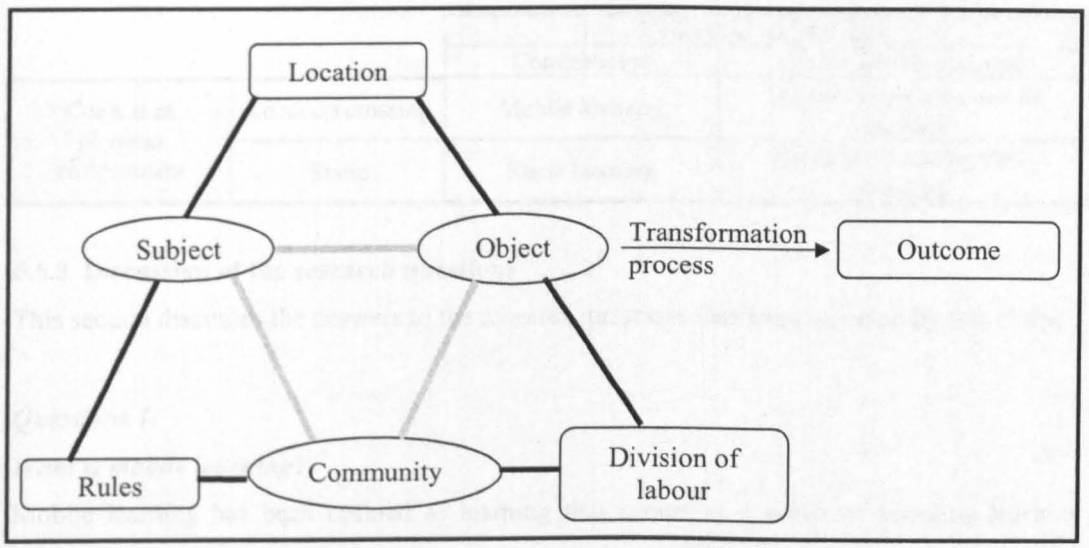
In the second definition, context is represented as the location where the learner is and how the properties of that location affect the learning activities. Context crossing here implies location crossing as context changes for each location. Therefore, the second definition of context is sufficient for defining mobile learning based on the idea of location crossing but it discards the social context of the learning activities which help with studying what is interesting about mobile learning, as discussed by Roschelle (2003) in Section 2.3. For instance, this conception of context can be applied to an example derived from the Ambient Wood project (Rogers et al., 2004) where a group of students used PDAs while conducting a fieldwork exercise. The devices were used to present images of plants to students to draw their attention to particular aspects of the environment. Students also used their devices to collect data (e.g. moisture and light) through sensors. Learning in this example is considered mobile because students are pursuing learning activities across locations. However, there will be no indication of the changes in the social context that occur as a result of using the technology, which would show what makes using portable devices for learning fun and socially interesting. Therefore, what makes learning activities socially interesting is for the social context of learning activities to develop in some way.

Thus, the discussion above and in Section 5.5.2 shows that for studying mobile learning both conceptions of context (physical and social) should be considered. Similarly, Sharples et al. (2007c) conceptualised the context of learning as both the physical environment and the community engaged in an activity. The conceptualisation of 'context' used in this thesis is based on that, considering both the physical and social factors that affect learning practices using Engeström's expansion of activity theory. However, Sharples et al.'s (2007c) conceptualisation has been extended. A change in the physical context is interpreted as a change in the location where learning activities take place, which also determines whether learning is mobile or static. A change in the social context is interpreted as a change in the rules and the division of labour that govern the students' community which shares the same objective, which also determines whether or not the situation is innovative. Using this analysis of the activity system of mobile learning is simpler than Sharples et al.'s (2007c) two layered version of Engeström's expansion of activity theory as it focuses on the collective context embodied in the physical and social setting of learning activities. The approach used in this thesis is differentiated from Sharples et al.'s (2007c) approach by the way the interplay between the physical and the social conceptions of context are understood, and the way social context is conceptualised. This is shown in Figure 6-16 and in Chapter 7 where this conceptualisation of context is used to analyse and study mobile learning.

In conclusion, neither concept of context crossing alone is a good basis for researching mobile learning. It is apparent that what is actually interesting when studying mobile learning is the intersection of these definitions, where mobility happens as a result of location crossing and at the same time changes taking place in the social context, which makes mobile learning socially interesting. The activity system triangle in Figure 6-16 shows the representation of mobile learning based on the idea of context crossing where location is represented in the activity system as the tool that enables mobile learning. Therefore, mobility happens when the subject and object are preserved, but the location (conceived as a tool, and including tools that facilitate learning (old and new)) is changed. Devices can be conceived of as part of the physical location as they are the tools that enable learning, at the same time, devices enable social practices and thus can be part of the social context. For example, if a student uses his laptop during a lecture to communicate with others through instant messaging software, the laptop is part of the physical location that enables social practices. Under this reformation, the social context, presented in the community, rules and division of labour, of the activity system may or may not change. The situation becomes interesting, socially, when the bottom half of the activity theory triangle also changes. In contrast, Sharples et al.'s (2007c) representation of context in the activity system of mobile learning was done through the 'community' component alone which was argued to represent both the physical environment and the

community of actors (people and interactive technology) who interact around shared objectives.

Figure 6-16 Framework for analysing mobile learning (Wali et al., 2008a)



The figure above is used in the remainder of this thesis to analyse the cases and identify mobile learning. This also helps with validating the conception of mobile learning that is proposed in this chapter. The figure contrasts with the activity system triangle proposed in Section 3.4.3 to analyse the cases in the studies conducted in this research. Initially, the tool component of the activity system was conceived as the device (portable and conventional) used to facilitate learning. This component is used in the framework above to address the location where learning activities take place.

Summarising these discussions, Table 6-8 is proposed to be used to distinguish mobile and static learning as well as socially interesting mobile and static learning. It is based on the conception that mobile learning can be defined based on the concept of context crossing where context is the combination of the location where the learning activity is taking place and the social setting, represented as the rules and the division of labour of the community, of the learning activities (Wali et al., 2008a). In this table, the intersection between context as a change in location and context as a change in social settings helps with identifying socially interesting mobile learning. However, it should be noted that as a consequence of activity theory's historical perspective, what makes mobile learning socially interesting may dwindle over time, in which case learning that was interesting may become ordinary because the change became part of the routine practice. Learning will still be either mobile or not; the historical aspect only affects one of the two dimensions when analysing a case. The table is

used in the next chapter to form the sampling frame for including cases in the Findings section.

Table 6-8 Illustration of context crossing as a basis for defining mobile and static learning (Wali et al., 2008a)

		Context as social setting	
		Conventional	Social setting changing
Context as physical environment	Location crossing	Mobile learning	Socially interesting mobile learning
	Static	Static learning	Socially interesting static learning

6.6.3 Discussion of the research questions

This section discusses the answers to the research questions that were revealed by this study.

Questions 1:

What is mobile learning?

Mobile learning has been defined as learning that occurs as a result of pursuing learning activities that are directed towards the same objective in different contexts considering both the physical as well as the social setting of learning activities.

Question 2:

How do students in HE utilise portable technologies in formal and informal settings?

Students in the study could only be observed in formal learning settings. Students were found to use a combination of portable technologies (e.g. laptops) and conventional devices (e.g. handouts) to aid their learning.

Students used their laptops in formal settings to aid their learning activities. They were expected by their instructors to use their devices to view lecture slides, follow the instructor's illustration and take notes. Students believed that to be a factor that encourages them to use their portables inside the classroom. Students also used their laptops to subvert formal education by using them to communicate with others inside and outside the classroom and to engage in activities that are not related to the lecture such as reading/writing emails and reading newspapers. Students attributed that to the nature of portables which can easily be used to subvert formal education without being noticed.

Students were also found to use conventional devices to aid their learning activities in formal settings. Students used handouts to view lecture slides, follow the instructor's illustration and take notes. Some explained that using handouts enabled them to take notes much quicker

when writing than when using their laptops for the same purpose. In addition, it was found that the short battery life of portables and the limited availability of power sockets limited students' utilisation of portables in formal settings.

The questionnaire responses showed that students' utilisation of portables in formal learning settings is different to their utilisation in informal learning settings. Students' reported that they use their laptops to carry out tasks that they can not perform in the class such as browsing the internet and using instant messaging applications. However, the class observations showed that students carry out these activities in formal settings as well. It was also found that the availability of Internet connection affects students' utilisation of portables in informal learning settings as students would use their portables more often in the cases of available Internet connection. In addition, it was found that mobility, accessibility to information and learning resources, and the availability of portables among all students encourage them to use their portables in informal settings. It is important for subsequent studies to investigate if the findings are replicated. Subsequent studies should also investigate students' utilisation of portable devices in informal settings through observations to reflect on the activities that students pursue in these settings and whether these differ from the activities pursued in formal settings. This would also help investigate the relationship between context and learning activities.

Focus Question 1:

How does the use of portable technologies differ when they are supplied as part of a study, rather than when they are used by students as part of their routine study practices?

Some of the students in the study were using their portable devices as part of their routine study practices. The students reported that they depend on their portables for their learning and communication practices and loosing these devices would have a major impact on their learning. The availability of the devices and the resources that enable using these for learning activities influences how students are dependent on the devices for their learning practices. This also influences the extent of technology utilisation for learning practices. These issues can be further investigated in subsequent studies. In addition, 2nd and 3rd year students' utilisation of portable devices can be compared to 1st year students who can be considered less immersed in using the technology, to represent students that are supplied with a technology as part of a study.

On the other hand, although some students had laptops, they chose to use conventional devices (printed lecture slides and handouts) to aid most of their learning activities. This issue

will be further investigated in subsequent studies through interviewing students to clarify the reasons behind that.

Focus Questions 2:

What is the influence of portable technologies on HE students' practices?

The study showed that students benefit from portables' mobility/portability, accessibility of information and learning resources, and communicative abilities to aid their learning in both formal and informal settings. It was also found that the availability of portables enables students to pursue learning activities that, without the technology, they can not pursue such as instant searching for information. On the other hand, it was found that portables can easily be used to subvert formal education and their short battery life limits their utilisation by students.

Question 3:

What is the relationship between context and students' learning activities?

The study showed that the social context including the rules and division of labour of learning activities affect students' utilisation of portable devices for learning in formal settings and the applications that students use in these settings. For example, the observational data showed that the nature of the course and the setting of the lecture affect the activities that students use their devices to accomplish. This finding can be further investigated in subsequent studies to check if it is replicated.

Learning activities are also influenced by the physical context where these activities are situated. For example, the lecture theatre setting and the availability of resources such as power sockets, Internet connectivity and accessibility to learning resources influence learning activities. In addition, the devices' properties and limitations were found to influence learning activities. For instance, short battery life causes students to use conventional devices instead of portable technologies. In addition, the devices can easily be used to subvert formal education. This influence of context (social and physical) can be further investigated in subsequent studies by studying students' utilisation of portables in informal settings, which was not possible in this study. This enables more elaborating on the findings above and drawing comparisons between learners' activities in formal and informal settings and how these are influenced by context.

Focus Questions 3:

What is the impact of instructors' portables use on students' utilisation of portables?

It was shown that the expectations of instructors of students' portables utilisation affect students' utilisation of portables. For example, students were expected to use their portables

to carry out specific tasks such as downloading lecture slides and using specific applications to aid their learning in formal settings. In addition, students were usually advised by their instructors to use/look for additional online material and animations that help them in their learning. Students also chose not to use instant messaging applications inside the classroom to chat with others because they were asked by their instructors not to. Students' utilisation of portables was also shown to be influenced by instructors where students reported that they copy the style of their instructors' presentation slides. This issue can be further investigated in subsequent studies to clarify why students copy their instructors' presentations slides' style.

Focus Question 4:

What is the impact of context on students' communication?

Students were found to use multiple techniques to communicate with others (face-to-face, using portables and online communication) in both formal and informal learning settings. Students reported that they mainly communicate face-to-face with others in formal settings. This shows that despite the availability of portable devices, students still communicate with others face-to-face. On the other hand, students' communication in informal settings was found to be through face-to-face, using portables and online communication. The differences in the techniques students use to communicate with each other both in formal and informal settings will be followed up in the next study. This study showed that the technology is not changing students' communication but students are using it to communicate with others. The study also showed that students' communication in formal settings is influenced by instructors' expectation of students as instructors discouraged students from communicating with others while being inside the classroom. Nevertheless, some students were found to subvert formal education and use their portables to communicate with others. This question can further be investigated in subsequent studies by studying the influence of both the physical and social context on students' communication, especially in informal settings which could not be fully investigated in this study.

6.7 Conclusion

This chapter has described a study that was conducted to overcome the limitations of the pilot study and implemented the proposed changes to the study's data collection and analysis techniques. The study revealed that administering the questionnaires by asking students to complete them before leaving the class enhances the questionnaire's response rate. In addition, using the modified version of the mobile learning properties originally proposed by Sharples et al. (2007c) to analyse the data in this study helped with understanding mobile learning. The study also helped with understanding students' utilisation of portable devices (old and new) to aid their learning practices and provided the opportunity to study students'

utilisation of portable technologies (i.e. laptops) that could not be widely studied in the previous chapter. Moreover, the study provided a developed conceptualisation of mobile learning, based on the idea of context crossing and using activity theory. The study also helped with getting more answers to the research questions and raised some issues that need to be further investigated in subsequent studies. The study presented in the next chapter utilises the proposed changes of this chapter and investigates the issues raised.

Chapter 7

Main Study: A study of the Use of Portable Devices in Higher Education

This chapter discusses a study that was conducted to implement a number of changes that were proposed in the previous chapter for gathering and analysing the research data. The changes were intended to investigate higher education students' utilisation of portable devices for learning in ways that were not possible in the previous study to answer the research questions.

7.1 Changes to the study

This section discusses the changes proposed in the previous chapter and their implementation in the study presented in this chapter.

7.1.1 Methodological changes

One of the changes proposed in the previous chapter concerned the sample studied. In the previous two studies, the sample comprised all the students in the classes that were observed. This provided a general idea about students' utilisation of portables to assist them in accomplishing their learning practices. However, there was little focus on studying specific cases which made the research data limited in terms of providing adequate details regarding specific practices of students' utilisation of portables in both formal and informal settings. In addition, the collected data was limited in terms of studying students' mobile learning as it lacked details about the *continuity* of students' learning practices in different contexts. For these reasons, in this study, the sample comprised a small number of students from each group that was studied. The aim was to focus on a number of case studies that provide more focused information about students' utilisation of portables to accomplish learning practices in formal and informal settings.

Another limitation of the previous study was the lack of data about students' utilisation of portables in informal settings. This was due to some restrictions placed by the university which prevented the observations of students in informal learning settings such as the library and canteen. In addition, these prevented system monitoring software from being installed on students' laptops, which would have helped in providing details about portables utilisation in

informal settings. The inability to install the system monitoring software on students' portables also hindered triangulating students' questionnaire responses with their actual use of the technology. In this study, the university's agreement to observing students in informal settings and installing the system monitoring software on their laptops was granted. This was a result of personnel changes in the ethical committee in the university. The new members did not have any reservations regarding the observations or logging students' laptops.

Furthermore, the previous chapter proposed that first year students could be studied to investigate the difference between students' technology utilisation when used for a short time and when used to accomplish routine study practices, which this thesis aims to address. First year students were included to represent students with less expertise using portables for learning in comparison to second/third year students, who were the focus of the previous studies, who may be more immersed in using the technology for their learning. This helps with answering the first focus question regarding the difference between the utilisation of portables when supplied as part of a study, and that when they are used by students as part of their routine study practices.

7.1.2 Analytical changes

In the previous chapter, a conception of mobile learning based on the idea of context crossing was introduced. The conception was based on activity theory as it provides a framework to study students' learning activities that are mediated by the use of tools and considers the context of these activities. Mobile learning was defined as learning across contexts where context comprises of both the physical and social setting of learning activities. The physical context (including the device used to facilitate learning) was represented in an activity system as the tool that enables mobile learning, where mobile learning occurs when students pursue learning activities that are directed towards the same objective in different physical locations. The social context was represented in an activity system as the rules and division of labour that govern the community that the student belongs to. This conception of mobile learning is used in this chapter to analyse the research data and study mobile learning by looking for cases with criteria that match the four categories of learning proposed in the previous chapter (Table 6-8). This also helps with validating the new conception of mobile learning. The structure of the findings section in this chapter has been altered in comparison to the previous chapters' findings sections to reflect the changes introduced to the data analysis. The changes to the structure of the findings section enables reflecting, triangulating and discussing the findings of the data collected through all research methods in relation to each theme of this thesis. Thus, the findings section is divided into multiple segments; each discusses the findings of one of the main themes of this thesis obtained through all the research methods.

7.2 Study setting and sample selection

The study was conducted in February/March 2007 in the same university as the previous study presented in Chapter 6. The university supplies both students and instructors with portable technologies (laptops) to aid learning and teaching practices. The university follows a system that is based on providing students with a set of lectures supported by tutorials and lab sessions. In addition, some courses are taught completely online while others are taught partially through lectures and students are expected to do some work online as well. Access to the university was obtained to study students' utilisation of portables in both formal and informal settings. Students in three groups where approached and asked to take part in the study. Students' participation included observing them in both formal (e.g. classroom, laboratory and tutorial rooms) and informal (e.g. university library and canteen) settings, installing system monitoring software on their laptops, answering a questionnaire and conducting interviews. The following is a description of the groups that the participating students belonged to:

Intermediate Cycle (IC) students

This group of students were third year medicine students and were in hospital placement. They were given lectures as well as hands-on tutorials and clinical observation sessions. Students were sent an email providing them with information about the study and asking them to participate in the study. Four students agreed to take part in the study. The group was studied for seven days.

Junior Cycle (JC) students

This group were second year medicine students. Their schedule included lectures, tutorial and lab sessions. Students were asked to take part in the study by talking to them at the beginning of a lecture and asking them to complete and return the distributed consent and authorisation form. Five students agreed to take part in the study. This group was studied for 14 days.

Foundation Year (FY) students

This group were first year medicine students. Their schedule included lectures, tutorial and lab sessions. Students were approached through email. Only two students agreed to participate in the study. The group was studied for five days.

7.2.2 Formal learning setting

Students in all three groups were studied in formal learning settings during lectures, lab sessions and tutorial sessions mainly through observations and log files. The questionnaires

and the interviews provided more information about students' utilisation of portables in these settings.

Intermediate Cycle (IC) students

The intermediate cycle students were observed during the clinical observations, hands-on tutorials and lectures. The lectures were held in the hospital's lecture theatres and the tutorials were held in the hospital's tutorial rooms. These rooms were equipped with a personal computer, data projector, flip chart, and an x-ray display device. Instructors usually used the personal computer to display lecture slides that were downloaded from external memory devices. Occasionally, some instructors used the x-ray display device during lectures to display x-rays of real patients to facilitate lecture discussion. Most students used their laptops to view lecture slides and take notes. Some used printed versions of the lecture slides to follow the instructor's illustration and take notes.

Students were also observed in some hands-on tutorial sessions which were held in examination rooms, tutorial rooms or patients' rooms. During these sessions, students were expected to practise diagnosing pretend or real patients by applying what they have learnt during the session or other previous sessions. Students were mainly moving around visiting patients and diagnosing them. Students did not use their laptops during tutorial sessions; instead, they used printouts of the material they needed and wrote their notes on these as well. Others used handbooks to write down their notes. Students were also observed in one clinical observation session that was held in an eye clinic. The clinic observation was expected to be useful for studying mobile learning; however, the session covered a topic that was new to students and was not related to what students were taught in the hospital placement.

Junior Cycle (JC) and Foundation Year (FY) students

These two groups were placed in the university. The junior cycle students were observed in the following courses: Cardiovascular and Respiratory, Molecular Medicine, Genitourinary/Endocrine, Histology and Clinical Competencies. In addition, the foundation year students were observed in the following courses: Introduction to general, medicinal and pharmaceutical chemistry; Introduction to medical physics; Introduction to human biology; and Chemical processes. Some of the foundation year students, those who did not pass an English language exam, attended an English language course. Most of these classes ran for an hour according to a schedule.

For these two groups, most lectures were held in the same classroom. The classrooms were equipped with a laptop for instructors' use, data projector, overhead projector and a

whiteboard. Instructors usually used the laptop to display the lecture slides which were downloaded from the VLE, the instructor's home directory or an external storage device.

Most students in these groups used their laptops to download lecture slides (PowerPoint presentations) that were previously uploaded on the VLE. Students varied in terms of the techniques they used to view the lecture slides and take notes during lectures. Most students used their laptops to view lecture slides and take notes. Some used printed versions of the lecture slides to follow the instructor's illustration and to take notes. Others used their laptops to follow the instructor's illustration but were writing down their notes on their handbooks.

Most lectures were supported by tutorial and lab sessions. The tutorial sessions where held in small tutorial rooms equipped with a laptop for instructors' use, data projector, overhead projector, and a whiteboard. In each group, students were divided into smaller groups and were assigned to different tutorial sessions. During tutorials, instructors usually used the classroom's laptop to display slides and discuss issues that have already been discussed in the lectures. Some instructors solved exercises during these sessions. The exercises had been given previously to students as homework. Students mainly listened to the instructor and used their laptops to look at the slides and take notes. Some students wrote down their notes in handbooks.

Students were also scheduled to attend a number of lab sessions which were held in a laboratory that is equipped with specimens of organs and body parts and other equipment for students' use. The lab sessions were mainly aimed to cover the topics that were previously discussed in the lectures and help students explore the specimens of the particular body parts and organs. During these sessions, instructors often used the lab's personal computer to display the lab sheet that includes a set of points that students need to cover during the lab session. Students had a copy of that in their lab handouts. The lab computer was also used to retrieve material from the Internet or the VLE to help illustration and discussion during lab sessions. Students were required to cover the points listed in their lab handouts. They used their lab handouts as a reference to the list of points that they need to cover and take notes. Some junior cycle students used their laptops during these sessions to refer to previous lecture slides that are related to the topic covered in the lab session. Students also used their laptops to search the Internet and retrieve any material placed on the VLE in relation to the lab session. Moreover, students occasionally referred to the books that were available in the lab which included images and descriptions of the topic being discussed.

7.2.3 Informal learning setting

Junior cycle students' portables utilisation in informal learning settings was studied through observing them in the university's library, log files, and questionnaires. The library was equipped with some specimens of organs and body parts and a human skeleton for students to use.

Two of the participants from the intermediate cycle were observed during a group meeting that was held in the hospital's canteen. The intermediate cycle participants could not be observed in many informal settings because they were scheduled eight lectures a day with only one hour break which they used to have a quick snack. The foundation year participants' informal learning activities were studied through log files.

7.3 Data collection

The study data was collected through questionnaires, observations, log files and interviews. Table 7-1 shows a summary of the data collected in the study.

Table 7-1 Summary of the data collected in the study

Group	Total number of students	Method	Total gathered data
Intermediate cycle	4 participants (IC1, IC2, IC3, IC4)	Questionnaires	3 students (IC1, IC3, IC4)
		Observations	*Formal:* 7 days for a total of 13 hours in multiple lectures and tutorial sessions *Informal:* a 30 minute group meeting in the hospital canteen
		Log files	4 students - (a screenshot is captured every 30 seconds) *IC1:* 6201 screenshots in 9 days *IC2:* 16655 screenshots in 9 days *IC3:* 7541 screenshots in 9 days *IC4:* 9088 screenshots in 9 days
		Interviews	3 students *IC1:* face-to-face (2 instances – 10 minutes) Instant messaging software (2 instance) *IC3:* face-to-face (1 instance – 10 minutes) *IC4:* face-to-face (3 instances – 10 minutes) Instant messaging software (1 instance)
Junior cycle	5 participants (JC1, JC2, JC3, JC4, JC5) and 8 students who carried out interesting practices (JC6, JC7, JC8, JC9, JC10, JC11, JC12, JC13)	Questionnaires	4 students (JC1, JC3, JC4, JC5)
		Observations	*Formal:* all participants and in 14 days for a total of 24 hours in multiple lectures and lab and tutorial sessions *Informal:* a total of 8 hours in the university library
		Log files	5 students (a screenshot is captured every 30 seconds) *JC1:* 8846 screenshots in 9 days *JC2:* 9400 screenshots in 25 days *JC3:* 49533 screenshots in 28 days *JC4:* 458 screenshots in 2 days *JC5:* 21831 screenshots in 28 days
		Interviews	3 students – The duration of all interviews was around 15 minutes *JC1:* face-to-face (1 instance) *JC2:* face-to-face (2 instances) *JC3:* face-to-face (2 instances)
Foundation year	2 participants (FY1, FY2)	Questionnaires	2 students (FY1, FY2)
		Observations	*Formal:* 5 days for a total of 12 hours in multiple lectures and tutorial sessions *Informal:* (FY1) during a meeting with an instructor
		Log files	2 students (a screenshot is captured every 30 seconds) *FY1:* 14298 screenshots in 15 days *FY2:* 12327 screenshots in 12 days
		Interviews	2 students *FY1:* face-to-face (2 instances –15 minutes) Instant messaging software (1 instance) *FY2:* face-to-face (1 instance –15 minutes) Instant messaging software (2 instances)

7.3.1 Questionnaires

Nine (IC: 3, JC: 4, FY: 2) of the 11 participants completed the questionnaire. The questionnaire was sent to the students via email.

7.3.2 Observations

Students' were observed in both formal and informal settings. The observations also covered the rest of the students in the classes that were observed or who were in the library at the same time as some interesting activities were carried out by these students. These cases were first observed then approached to ask for their permission to use the collected data for the study. All the cases granted their agreement to use the observational data, which were mainly recorded as notes, for the research. Details about the duration of observations in formal and informal settings of each group are provided in Table 7-1.

7.3.3 Log files

The system monitoring software was installed in all the participants' laptops and was set to capture a screenshot every 30 seconds (15 seconds for one participant). This was a human error as the researcher forgot to change the default software setting for the time between screenshots. The time period for logging students' activities varies among students as some were approached later during the study while one participant (JC1) asked to uninstall the software from his laptop after a week. Data was collected from students' laptops by meeting them weekly and saving the log files to an external hard disk. A female participant's computer (JC4) was formatted in the second week of the study and all the captured data was lost. The software was not installed again as the student preferred not to have the monitoring software installed again. In addition, during the first week of installing the software, the monitoring software stopped logging two of the participants' (JC4 and JC5) activities because the log files folder's size exceeded the limit that was specified by the software. This problem was resolved by changing the folder's size option in the software to fit with students' estimated usage of their portables. Details about the total number of log files collected from each participant's laptop and the duration of logging the student's activities are provided in Table 7-1.

7.3.4 Interviews

Short face-to-face interviews were conducted with some of the participants during and at the end of the study to clarify some of the issues that were observed in formal and informal settings. In addition, students were contacted after the study through email and instant messaging software for clarification of some of the activities that were found in their log files. The interviews were structured using the observational notes and log files so the questions varied for each student. Details about the number and duration of the interview for each participant are provided in Table 7-1.

7.4 Data Analysis

This section discusses the analysis of the research data that were collected through questionnaires, observations, log files and interviews.

7.4.1 Questionnaire analysis

The questionnaire included open and close-ended questions that provided information about students' portables utilisation in formal and informal settings, the influence of portables on students' learning activities through listing the benefits and limitations of portables' usage for learning, portables' utilisation for communication in formal and informal settings, and the impact of instructors' technology utilisation on students' technology utilisation. The questionnaires were analysed as cases that report on the perceptions and portables utilisation of the people studied.

7.4.2 Observational data analysis

The observational notes were mainly searched for cases that help answer the research questions. The notes were also used to map the participants' activities recorded in the log files with the activities taking place in the different locations where the students were observed such as classrooms and the library. This helped with studying students' utilisation of portables in both formal and informal settings and validated the mobile learning conceptualisation proposed in the previous chapter. This was done by searching for cases that represent the different learning classifications presented in Table 6-8 which were proposed as part of the mobile learning conceptualisation and which classifies learning based on the context of learning activities. The observational data was also used to triangulate students' self reports collected from their questionnaires.

7.4.3 Log files analysis

The log files were analysed by examining them visually and looking for the applications that students used in formal and informal settings which provided an idea of the activities students carried out in these settings. Determining whether the applications were used in formal or informal settings was done through comparing the time that appeared on the screenshots, tagged by the logging software, and the student' timetable, and supporting that with observational data when this was available. However, in some cases, the physical location had to be inferred by studying the applications that students used, shown in log files, and the activities that they engaged in. This provided an idea of the location where learning activities took place in relation to where they are supposed to be in the timetable. In addition, in some cases, location was determined through the online conversations that students had with others. Students were also asked about where some of the activities have taken place through

contacting them via instant messaging software. However, students' self reports could not be validated using other methods and these responses had to be considered without validation. In some cases, studying the continuity of learners' activities clarified the aim of the activity and thus validated learners' responses. These techniques provided an insight on students' portables utilisation in formal and informal settings and provided information about the continuity of students' learning activities in different contexts which helped with studying mobile learning. Activities such as reading course materials, revising lecture notes, working on courses work and communicating with colleagues were determined using the log files.

7.4.4 Interviews analysis

The interview data were used to clarify unclear issues related to the observations conducted in formal and informal settings. Students were also contacted through emails and instant messaging software to clarify some of the issues that were found in the log files.

7.5 Findings

This section discusses the findings of the data collected from the participants as well as the other cases that were observed in both formal and informal learning settings. In all cases, students' consent to use the collected data for the study was obtained.

The structure and focus of this section differs from the previous studies findings sections. It presents the research findings according to the main themes of the research questions of this thesis, unlike the previous chapter where the findings were presented according to the research method used to collect the data and more focus was on understanding and conceptualising mobile learning. The structural changes, specifically Section 7.5.8, also align with the changes introduced to the data analysis in this chapter through using the conceptualisation of mobile learning and the classification of learning presented in Table 6-8 in the previous chapter.

7.5.1 Portables' utilisation in formal settings

The participants' questionnaires showed that the students use their laptops inside the classroom on a daily basis to view lecture slides, take notes, follow the instructors' illustrations, view pictures included in the slides, use the Internet and use online dictionaries and encyclopaedias. The log files and class observations validated that the students used their laptops for the above purposes. The observations supported by the log files also showed that students used their laptops to exchange lecture slides through Bluetooth or external memory devices especially in cases of limited wireless connectivity where they could not download the lecture slides from the VLE.

Moreover, the log files and class observations validated students' questionnaire responses about using their portables inside the classroom to communicate with others and ask questions. For example, participant FY2 communicated with colleagues inside the class and others outside the class; the log files showed that the student used instant messaging software to ask for help regarding software he wished to download. The student received a website link as a response. In addition, the student used instant messaging software to chat with a colleague inside the classroom regarding the lecture.

The log files also clarified that the participants used the Internet inside the classroom to view websites with and without some relation to the topics discussed during lectures. For example, participant FY2 used his laptop to visit websites suggested by instructors during classes, such as a website listed on one of the lecture slides to view a simulation program.

In addition, the foundation year and junior cycle participants, and the rest of the class, were observed during lab sessions that were held in the laboratory. In these sessions, instructors usually used a personal computer and data projector that were available in the laboratory to display material related to the topic discussed in the lab session. Most students did not use their laptops in these sessions; instead they used lab handouts. Participant FY1 was asked about the handout and she clarified that these are provided by the university for students' use during lab sessions. The lab handouts included a set of lab sheets that are related to the topics discussed in different courses' lectures throughout the semester. In addition, the handouts were usually used during lab sessions to refer to the points that students need to explore during these sessions and write down/draw their observations and notes. The handouts were also used by students to facilitate discussions and share representations during these sessions. The student explained that the handouts are handed to the instructor for grading at the end of the semester and are returned for exam revision as students are tested on the issues covered in the lab sessions. The participant clarified that for this reason, she and her colleagues use other resources to contribute to their answers in the lab handout such as getting help from each other, searching the web, reviewing their lecture slides and reading the lab session's corresponding online materials that are posted by the instructors on the VLE. For example, one of the observed lab sessions was about exploring and examining different kinds of tissues using a microscope. The instructor mentioned that he had posted a number of images of these tissues with a description of each on the VLE. The instructor also displayed and discussed some of these during the lab session. The participant clarified that students are asked by the instructor to get back to these resources to help with solving and understanding the lab session.

While most students did not use portables during lab sessions, some did. For example, participant JC1 was observed during a lab session using both his laptop and lab handout. The student clarified that he uses his laptop to refer back to the lecture slides that are related to the lab session to get help and more information about the issues that need to be covered during the session. The instructor was also asked about students' portable utilisation in the lab session and she clarified that sometimes students use printed lecture notes, handouts, books, and their laptops during lab sessions to get more information about the topics covered. This was also found during the lab observations.

The observations showed that students use a diversity of devices to aid their learning in formal settings such as laptops, handouts, handbooks and specimens. For example, some students used printed versions of the lecture slides despite the availability of their laptops during lectures and the fact that these can be used to view lecture slides and take notes. A couple of these students (JC6, JC7) were approached and asked about the reason for using printouts instead of their laptops and they clarified that they prefer to use printouts as they do not type fast which causes them delays in taking notes as the instructor illustrates. In addition, they clarified that they prefer to use printout resources to aid their learning in general. The same students were observed over the period of the study and their practices did not change. However, on a couple of occasions where there has been a swap in some lectures without students being notified, the students used their laptops to view the lecture slides and write notes. In these cases, students changed their practices to cope with the change in the setting and the unavailability of the tool (in this case printouts) that they usually use to facilitate their learning. From an activity theoretic perspective, the availability of the laptops resolved the contradiction (the unavailability of printed lecture slides) between the subject (student) and the tool (printed lecture slides) used to achieve the object (follow the instructor's illustration and take notes) of the activity. The students replaced the tool (printed lecture slides) that they usually used to view lecture slides and take notes with another tool (laptop) that enables accomplishing the objective of the activity. Similarly, the observations showed that participant JC4 changed her practices from using a laptop to aid learning during lectures, view lecture slides and take notes, to using printout versions of the lecture slides. This was due to a problem with the student's laptop which was taken away to be fixed. Moreover, the intermediate cycle students' observations that took place in the hospital showed that students used handouts and handbooks in all hands-on tutorial and clinical observation sessions. Students clarified that laptops are too big and heavy to be used in these settings, especially since students need to be standing and moving around most of the time. Students only used their laptops in the lecture halls which also took place in the hospital. These halls enabled

students to use their laptops more comfortably due to the availability of tables, wireless connection and power sockets.

The junior cycle students were scheduled a number of lectures for a course that is mainly delivered online. During one of these sessions, a student (FY7) was copying material, including text and images, from the online course to a Word document. The same student was observed on many occasions inside the classroom and was usually using printed material to view lecture slides and take notes. The student clarified that she will print the document to be able to revise the material. This also supports a previous conversation with the students where she clarified that she does not use her laptop to study and mainly prints material for that purpose. The case shows that despite the availability of an online course, the student preferred to use printed material to study the topics. Therefore, the advantages and the capabilities of the online course are not being utilised here because the student prefers to have printouts of learning resources for revision purposes.

Part of the foundation year class was observed in English Language classes. Those students did not pass the English skills test so they were required to attend English classes to improve their skills. In these classes, some students used their laptops to view the lecture slides and take notes while others were writing down their notes using handbooks. In addition, students used exercise sheets distributed by the instructor to solve exercises during the class. Some students referred back to the lecture slides to solve the exercises while others referred back to their handbooks. In this course, the instructor usually asked students to write short essays as homework and submit them through the VLE. The instructor then marked the essays and posted students' marks through the VLE. However, for the lectures that were observed, the instructor asked students to write the essays using their laptops during the two hour lecture and she corrected them at the same time by asking each student to bring his/her laptop to the instructor's desk for correction. Students were given their marks at the same time. During these lectures, some students used dictionary software that is installed on their laptops; others used online dictionaries.

All the devices that students used to aid their learning were also used to share representations and facilitate discussions. For example, the observations showed that students point to each other's laptops, handouts, or handbooks while discussing issues. In addition, it was shown that students did the same when asking instructors questions as they usually take their laptops with them to the instructor's desk and ask questions while pointing on their screens to refer to certain things on the monitor.

In conclusion, studying students' utilisation of portables in formal settings answers a part of the second research question: How do students in HE utilise portable technologies in formal and informal settings? The study showed that students use multiple devices (old and new) to aid their learning in formal settings. The devices are mainly used to accomplish curriculum-related tasks such as viewing lecture slides, taking notes, communicating with colleagues and discussing the topics discussed in the class and viewing online resources related to these topics. This is mainly due to the structure of sessions which are based around students using their portables to aid their session-related practices in formal settings. The devices are also used to accomplish social activities such as communicating with friends and family via instant messaging software and emails and visiting websites and performing tasks of personal interest. Students attributed that to the fact that laptops can be easily used to subvert formal education without being noticed. Lastly, the devices are used to accomplish administrative tasks such as preparing curriculum-related and personal (e.g. curriculum vite) documents and using time management tools such as a calendar.

The study also showed that despite the availability of portable technologies, some students still use conventional devices such as handouts to accomplish their learning activities in formal learning settings. This is due to some limitations of the portable technologies that can not be used in certain contexts. In addition, students' personal preferences about the way they like to approach their learning affects the choice of technology to facilitate their learning. Others expressed that they prefer to use printout versions of the learning resources due to the fact that they prefer to write down notes rather than typing them because they are slow at typing.

7.5.2 Portables utilisation in informal settings

All participants' questionnaire responses showed that they use their laptops on a daily basis outside the classroom. Students reported that they use their laptops to view lecture slides, write notes, view websites, chat with colleagues, ask questions, prepare for lectures, read previously given course material, work on assignments, play games, listen to music, read/ write emails, and read e-books. The log files and observations showed that students used their laptop to accomplish the activities mentioned above as well as other tasks such as viewing personal pictures, the timetable and calendar.

The log files clarified that students used the Internet outside the classroom to read online newspapers, watch movies, visit websites of personal interest and visit websites with images and videos related to the topics discussed in lectures. The Internet was also used outside the classroom to access the VLE to view resources, use the chat room to communicate with

colleagues and view discussions of college communities, clubs, courses' discussions and problem solving. In addition, the log files showed that the participants used the Internet outside the classroom to access online dictionaries and encyclopaedias. For example, participant FY1 clarified during an online conversation that she usually looks for more information about the topics discussed in the classroom through online resources which she takes notes of and sometimes writes down questions to be discussed with instructors. The student was observed during a discussion with an instructor. She used her laptop to refer to her questions and some of the points listed in the lecture slides. The log files also showed that most participants used the Internet outside the classroom to view web sites suggested by instructors. This was recognised where the students copied the web addresses from a lecture slide into the browser's page.

The log files also showed that the participants used their laptops to communicate with others for personal and educational purposes. For instance, participant FY2's log files showed that he used the Internet to chat with people and collaborate regarding lecture slides and used the web to help answer people's queries. In addition, the log files of participant FY1 showed that she used instant messaging software outside the classroom to communicate with a colleague and arrange for a group meeting to revise previous lectures and solve a tutorial. The student was asked through an online conversation about the purpose and what she and the group usually do in these sessions. The student clarified that they meet weekly to discuss and revise the material that has been covered in lectures during the week. She clarified that these meetings are not compulsory but they are arranged within the group as a way to help each other and to understand the material. She also mentioned that not everybody in the class does that.

In addition, the log files showed that the participants printed some lecture notes to be used in informal learning settings. For example, participant FY1 was asked through an online conversation about printing a set of lecture slides of a course (Biology) and she clarified that she does that only for that course as the slides include lots of details and need more time to be understood. In addition, the student clarified that she prefers to use printouts for this course as this keeps her away from her laptop and the possibility to chat and do other things than studying. The student clarified that she gets back to the printouts when she wants to revise the lecture slides. However, the student mentioned that she does not depend totally on the printouts as she still uses her laptop to view the slides during lectures and when revising especially to view any images in the slides and to take more notes as she is revising.

The observations showed that students use laptops, mobile phones, handouts, handbooks, books and specimens as learning aids in informal settings. For example, many cases were observed in the library where students used specimens to facilitate group discussions. In these cases, students had the lecture slides that are related to the specimen printed out or displayed on their laptops and used these to help explore the specimen. In addition, a number of cases (JC7, JC11, JC12, JC13) were observed in the library where students rewrote the notes they usually take during lectures on the lecture PowerPoint slides to printout versions of the lecture slides or in handbooks. Students clarified that they prefer to revise from printed material for exams and some suggested that they understand better when they write down notes. Others explained that they abandon using their laptops for exam revision as this causes them sight problems and therefore, they prepare their learning resources for exams beforehand throughout the semester by using printed versions of the relevant learning resources.

In conclusion, studying students' utilisation of portables in informal settings helps with answering the second part of the second research question: How do students in HE utilise portable technologies in formal and informal settings? The study showed that students use multiple devices (old and new) to aid their learning activities in informal settings. The choice of the device used mainly depends on personal preferences about the way students like to approach their learning. Portables were used to accomplish curriculum-related tasks such as revising lecture slides, working on assignments and discussing issues with colleagues. Portables were also used to accomplish social tasks such as communicating with friends and family and engaging in forums of personal and educational interest. Moreover, portables were used to accomplish administrative tasks such as using emails to arrange for meetings, performing time management tasks (e.g. calendar); viewing schedules and preparing documents for further use.

7.5.3 The difference between using portable technologies when supplied as part of a study and when they are used as part of students' routine study practices

To address this issue, this study investigated 2nd/3rd year students' utilisation of portables for routine study practices and compared that to 1st year students' utilisation of the devices. This was based on the assumption that 1st year students can represent students with little expertise of using portable devices to mediate their learning activities as, in this study's setting, they have been using laptops to aid their learning for a shorter time than 2nd/3rd year students. It was also assumed that 2nd/3rd year students can be studied to represent students for whom their portables are already integrated into their routine learning practices. This helps with studying students' established use of the technology to accomplish learning practices, which this thesis aims to address. However, although the number of 1st year participants in this study does not

represent the population of students using a technology as part of a study, the year of study does not seem to determine how immersed students are in using a technology to mediate their learning.

The study showed that the number of 1st year students who used conventional devices instead of laptops to aid their learning practices is less than that in 2nd/3rd year students. This shows that although 1st year students have been using laptops for a shorter time in higher education, they may be more dependent on the technology than those who have been using it for a longer time in this context.

On the other hand, the study showed that when portables are used as part of students' routine study practices (e.g. 2nd/3rd year students), students use the devices to accomplish a wider variety of activities than the students that have been using the devices for a shorter time (e.g. 1st year students). For example, the intermediate cycle students (3rd year) used their laptops to share documents and facilitate discussions, whereas the foundation year and junior cycle students did not use them much.

The study also showed that one factor that influences students' adaptation and utilisation of portable devices to accomplish routine learning activities is the level of integration of the devices in students' learning by the educational institution. In the study, portables were provided to students by the university and were made part of students' curriculum where students were expected to use them to accomplish their routine learning practices. The students reasoned that the availability of devices and the resources to use the devices and the continuity to use these across the years made them more dependent on the technology to accomplish most of their practices. Students' utilisation of laptops in this study was also widespread and more integrated in students' learning activities than the students in the pilot study where portables were not available to all students. The study also showed that the availability of the devices and resources affects the way portables are used and the level of technology integration in students' learning practices. For example, students in this study were found to use their portables to accomplish most of their learning, communication and administrative activities. This is because the university provided students with these devices and built the curriculum around using these to accomplish learning objectives. Students also believed that losing their portables will have a major impact on and may hinder them from achieving their learning objectives. For example, participant IC3 clarified that she did not recognise the benefits of using her laptop to achieve learning objectives when the device was first provided to her by the university. But, after three years of using the technology, she clarified that she cannot give up her device and could not achieve her learning objectives

without it. This also shows that proper training is needed for students when they first are provided with laptops to ensure utilising the benefits of the device for students' learning.

On the other hand, the study showed that although integrating a technology in students' learning practices encourages use, it does not necessarily mean that students will use the technology to achieve their learning objectives. For example, in this study, although laptops are integrated in students' learning by the university, some students preferred to use conventional devices to accomplish their learning activities. This was due to personal preferences as some clarified that they prefer to use printout resources and write down notes rather than doing that using their laptops.

Therefore, the time spent using a technology is not the only factor that determines the extent of the technology's integration in students' learning practices. It is also affected by personal preferences and context.

7.5.4 The influence of portables technologies on students' practices

The second focus question in this thesis is: What is the influence of portables technologies on students' practices? The answer to this question was investigated by studying the benefits and limitations of these devices when used by students to accomplish their learning practices. The study showed that using portables to aid students' learning provides a number of benefits such as the convenience and accessibility to learning resources which aids the ability to engage in learning activities in different contexts. Students expressed that portables enabled having all the needed resources and the ability to access these through one device. In addition, conversations with students revealed that students perceive the portability/mobility of the devices as a key benefit because this enables them to engage in learning activities in multiple contexts. Students also perceive portables as being useful for managing documents and tracking notes and lecture material. Participant IC4 clarified that he usually arranges all relevant information from different resources such as books, the web and his own notes in documents and folders for easy access. The student mentioned that he perceives arranging learning resources using technologies easier than doing the same using printed materials. In addition, participant IC1's log files showed that the student edited the printed material that he usually uses during hands-on tutorial sessions and added more information to these. The student was asked about that and he clarified that he usually copies the notes that he takes during the tutorial sessions on printed material to the electronic document on his laptop. He also mentioned that he looks for more information about the topics on the web and adds these to the document. The student clarified that this helps him to have all the information that is related to a specific topic in one document and all the documents that are related to the same

course in one folder. The student uses the documents later for revision. This answers a question that was proposed in Section 6.5.1 regarding how students keep track of their notes and lecture material.

The participants' questionnaires showed that students find laptops to be useful for use in formal settings as they enable students to carry out many activities that help them to understand the topics discussed during lectures such as to view lecture notes, follow instructors' explanations, view media and search for information. These activities were also found in observations of students inside the classroom. In addition, the participants perceived laptops to be useful for activities in informal settings as they enable carrying out activities which can not be done when using conventional devices such as accessing lecture notes, time management and information searching through the Internet. Students also mentioned that mobile phones are useful for time management activities and communication purposes especially outside the classroom.

The participants' questionnaire responses did not identify any limitations that they encountered as a result of using portable devices to aid their learning. However, studying the intermediate cycle students showed that students did not use laptops during hands-on tutorial sessions and clinical observation sessions because these devices are heavy and too big to be held for a long time and moved around. In these cases, students replaced laptops with handouts and handbooks. This shows that the properties of the devices affect students' ability to use these in certain contexts. In addition, through conversations with the participants, most mentioned that the connectivity to the Internet through laptops gives them the opportunity to engage in practices that distract them from studying at home or listening to the instructor's illustration during lectures. The observations supported that as a large number of the students subverted formal education during lectures by engaging in activities that are not related to the lecture such as chatting with others, browsing the web, reading/writing emails, playing games, and watching videos. This shows that portable technologies not only can be used to facilitate learning in formal and informal settings, but they can be easily used to engage in activities that distract learning. Other factors that limit the utilisation of portables and thus influence students' practices in formal and informal settings are: short battery life, the limited number of power sockets, lack of privacy and the availability and speed of internet connections.

7.5.5 The relationship between context and students' learning activities

This subsection attempts to answer the third research question: What is the relationship between context and students' learning activities? The study showed that learning activities are affected by the physical (location) and social (rules and division of labour governs the

community engaged in the activity) contexts of these activities. For example, the study showed that in formal learning settings students mainly engage in activities which help with achieving the goal of the sessions (developing understanding of an issue) such as viewing lecture slides and taking notes. Students' conversations, observations and log files clarified that students limit their use of portables to engage in online discussions with others inside the classroom because instructors ask them not to.

It was also shown that context affects the choice of device that students used in different settings based on the features of the setting. For example, the intermediate cycle students who usually use laptops during lectures used different types of devices to aid their learning during hands-on tutorial sessions in the hospital. This was due to the setting of the tutorial sessions that required students to have small and light devices that could be carried around easily and used to view learning resources and take notes. This is also affected by the features of the technology which may enable or hinder using the devices in certain contexts. In this example, the laptops' limitation of being big in size and heavy in weight hindered using them in situations that require students to be on the move.

Not only learning activities are affected by the context of the learning setting, but using portable devices creates contexts other than the context that the student is part of. For example, many cases (e.g. IC1, IC2, IC3, JC3) were observed where students are in the classroom using their laptops to communicate with others through instant messaging software. In these cases, students create a different context than the one they are part of which is the combination of the properties (availability of wireless connectivity) of the classroom and the rules (view lecture slides and write notes) and division of labour (students/instructor) within the students' community (students and instructor). The context created in these cases includes the student and the other person engaged in the online discussion as the community, which changes the rules (write a message and read response) and division of labour (reader and writer) governing the learning activity.

7.5.6 The impact of instructors' portables use on students' utilisation of portables

In answering the third focus question, about the impact of instructors' portables use on students' utilisation of portables, the study showed that instructors affect students' utilisation of portables both directly and indirectly. For instance, the impact of instructors on students' utilisation of portables was clear in participant FY2's questionnaire response. The student reported that he copied an instructor's presentation styles when developing his own presentations. When asked, he clarified that the instructor suggested that students adapt his presentation style to develop their own presentations. The log files also supported that as the

student was viewing a set of slides created by an instructor and adapting and copying the style to his slides.

In addition, instructors' expectations of students' technology utilisation unconsciously influences students' behaviours and their utilisation of portables. This was shown in most of the participants' questionnaire responses as students reported that they are encouraged to use their laptops when instructors require them to look for websites showing animations, e-books and articles that help with understanding topics. This was also noticed in the log files as some students looked for online resources that were suggested by instructors in the lecture slides. The observations supported this conclusion as in some instances instructors were asking students to visit certain websites for media that help with clarifying and understanding the topics being discussed in the classroom.

In addition, during a class observation, the instructor solved some questions with students. The instructor mentioned that the questions have been posted on the courses' discussion forum but only a few students contributed and solved these while he expected more students to contribute. Participant JC3 was asked about that and she clarified that students are asked to solve the question, but they do not have to as these are not marked by the instructor. This shows that one reason that students did not solve the exercises and contribute to the discussion forum is that the instructor did not motivate students to do so. Students knew that the instructor will solve the questions anyway in the class and that is why they did not solve the exercises.

Students' technology utilisation is also affected by their expectations of instructors' technology utilisation. Students' questionnaire responses showed that instructors' technology utilisation did not put them off using the technology to aid their learning. In addition, conversations with participants clarified that students perceive their instructors to be experts in using the technology which encouraged students to use their devices more. Moreover, the conversations showed that students did not witness bad experiences of instructors' utilisation of portables that might put them off using the technology to aid their learning as they did in the previous study.

7.5.7 The impact of context on students' communication

This subsection explores the answer to the fourth focus question: What is the impact of context on students' communication? This question is explored by looking at both formal and informal settings. This also helps with exploring the similarities and differences between students' communication in these contexts.

Formal settings

The participants' questionnaires showed that students engage in face-to-face discussions with others in formal settings. This was also found in the observations of students as many instances of face-to-face discussions have been observed in classrooms, lab and tutorial sessions where students asked questions and discussed issues (both personal and educational) with colleagues as well as instructors. The observations showed that students' face-to-face discussions increased in lab settings. This is because these sessions were designed to encourage students' discussions by arranging students in groups and assigning goals to each group to be achieved by the end of the session. In these sessions, students used different resources to share representations and facilitate their discussions, such as laptops, handouts, handbooks and specimens. Students usually used the handouts to refer to the points that they are required to investigate during the sessions. They also used the Atlases available in the lab to look for more information about the topic and specifically illustrating images. In addition, the observations clarified that students use conventional devices such as handouts and hand books to communicate and write comments to each other.

Students also used portable devices to facilitate their communication and discussions in formal settings. The observations showed that students use the notes area in PowerPoint to write notes to each other. In addition, the questionnaires, observations and log files showed that students, including the participants, use instant messaging software during classes to communicate with each other to discuss questions about the issues illustrated in the class. The log files also showed that students use their laptops during classes to communicate with friends and family and discuss issues not related to the topics discussed in the classroom such as personal issues, arranging meetings, solving problems, sharing representations and sharing files such as lecture slides especially in cases of limited wireless connectivity. For example, the log files and class observations for participant JC2 showed that he was chatting with someone and at the same time looking for flights through an online booking system for a trip for that person. The student was continuously sending the other person the results of his search queries through instant messaging software.

The study showed that although instructors make it clear that they do not like students to use instant messaging software in formal settings, students still use these to communicate and discuss issues with others. The properties of the devices enable students to engage in such activities without being noticed by instructors. At the same time, some students expressed that they limit their usage of instant messaging software in formal learning settings to conform to the rules within the context.

The log files also showed that students use emails and discussion forums to communicate and discuss issues with both colleagues and instructors. For example, the intermediate cycle students' log files showed that students exchanged emails to arrange for the tasks that need to be accomplished to complete a group project. They also arranged group meetings, discussed issues and exchanged files related to the project through emails and instant messaging software.

Informal settings

The study showed that students communicate and engage in discussions in informal settings more frequently and freely than they do in formal settings. This is mainly because of the context as students are not under any restrictions enforced by instructors or the setup of classrooms and labs.

The participants mentioned that they use instant messaging software on a daily basis outside the classroom to discuss and ask questions regarding the issues illustrated inside the classroom, discuss things not related to these topics, and chat with friends and family. The log files showed that there were instances where the participants used instant messaging software to communicate and help answer others' queries. For example, in several instances, participant FY2 has been approached by colleagues via instant messaging software asking about issues included in specific lecture slides. The student then opened the slides file, looked for the specific slide and answered the questions. In addition, the participant's log files showed that he used the Internet to look for answers for people's queries. For instance, the participant was approached by a person who was asking about a specific digital camera model; the student used the web to search for that model and sent the search result to the person.

In addition, the observations supported by the log files showed that the participants combine different techniques to facilitate their discussions with others. For example, two of the IC participants (IC2 and IC3) used both laptops and mobile phones to discuss issues and communicate with each other. The log files showed that they used their laptops to discuss issues related to the topics illustrated in the classroom, revise the topics together while each being in a different location and arrange a time for that. The log files also showed that the participants used their mobile phone to discuss personal issues. This was shown by the conversations students held using their laptops as they mentioned some phone calls. The conversations also showed that students agreed to print the lecture slides, revise them while each was in a different location and then discuss the issues covered in the slides through instant messaging software.

The questionnaire also showed that the participants communicate and discuss issues (both personal and course-related) with other students face-to-face on a daily basis outside the classroom. The log files showed that students arranged for their face-to-face meeting through instant messaging software. For instance, participant FY1 used the VLE's chat room to arrange a group meeting. In addition, many cases of face-to-face collaboration outside the classroom were observed in the library where students usually sat in groups and discussed issues related to material they have been given in lectures, tutorial sessions and lab sessions. In these instances, students used their laptops to refer back to some materials as well as share representations. Students also used other resources such as books, handouts, handbooks, mobile phones and specimens to facilitate their discussions.

In conclusion, and reflecting on the impact of context on students' communication in both formal and informal settings, the study showed that students' communication is affected by the context (physical and social) of learning activities. This also affects the method (e.g. face-to-face and through portables) and the type of device (new or old) students use to facilitate their discussions. For example, the log files have shown that students use instant messaging software in informal learning settings more than using them in formal learning settings. One reason that might have affected students' discussions with others in formal learning settings is the social setting of lectures and tutorials, as these were mainly based around the instructor's explanation. This affected students' practices as their engagement with their portables tended to focus on following the instructors' illustration and taking notes. In addition, it was apparent during lecture observations that instructors discourage students from using their portables for communication purposes inside the classroom as instructors asked students not to engage in such activities. This reflects the impact of instructors' expectations on students' practices. In this case, the influence of context is embodied mainly in the social context including the rules (listen to the instructor's explanations, view lecture slides and take notes) and the division of labour (students/instructor) within the students' community (students and instructor). The social context of learning activities in informal settings develops as a result of changes in the rules and division of labour of the students' community which enable students to engage in discussions without any restrictions from the instructor.

In addition, the physical context embodied as the classroom and the services available within that, such as the availability of wireless connection and portable technologies, affect students' communication. For example, in some cases in the study students could not use instant messaging software when the wireless connection was weak or not available. This caused students to engage in activities other than chatting. In addition, some cases showed that despite the availability of portable devices and the ability to communicate with others through

these, students choose to communicate face-to-face. This supports a finding in the previous study that the technology that students use is not changing the way students cooperate; instead, students use the technology to facilitate their discussions. Moreover, the study showed that the change in the physical context did not always change students' practices. For example, students in hospital placement kept doing the same practices that they used to do in the university such as using instant messaging software during lectures.

7.5.8 Classification of students' learning

This subsection aims to validate the conception of mobile learning that was proposed in the previous chapter. It also helps with addressing and answering the first research question: What is mobile learning? This is done by applying the conceptualisation of mobile learning proposed in the previous chapter to real-world cases extracted from this study's data and studying students' activities that are mediated by the use of tools in relation to the context of these activities. Studying students' learning activities was mainly done through observations and log files which reflected the routine learning activities that the students pursued and the continuity of these in different contexts such as the classroom, laboratory, library and home. Studying the students' activities in these contexts provided an insight into their mobile learning. As discussed in Chapter 6, Engeström's (1987) expansion of activity theory is used to study mobile learning based on the idea of context-crossing, where context is represented as both the physical and social setting of learning activities. A change in the physical context is interpreted as a change in the location where learning activities take place which also determines whether learning is mobile or static. Location is represented as the tool that enables mobile learning. A change in the social context is interpreted as a change in the rules (norms that govern the learners' community) and the division of labour (organisation of the students' community that shares the same objective) that govern the community engaged in the object of the activity and which makes learning socially interesting. Based on this, the table below was introduced to help distinguish mobile and static learning and socially interesting mobile and static learning.

Table 7-2 Illustration of context crossing as a basis for defining mobile and static learning (Wali et al., 2008a)

		Context as social setting	
		Conventional	Social setting changing
Context as physical environment	Location crossing	Mobile learning	Socially interesting mobile learning
	Static	Static learning	Socially interesting static learning

The remainder of this section is divided into four segments. Each discusses one type of learning introduced in the table above using both portable technology and conventional devices to show that the different types of tools (both old and new) can enable the same type of learning.

Location crossing – Changing social settings

Portable device

The continuity of participant FY1's learning activities across different spaces that was shown in the log files provided an idea of the student's mobile learning. The student used her laptop to view lecture slides in the classroom, revise these at home and use them to facilitate group discussion during a group meeting. The space that the student was in was determined based on the conversations that took place through instant messaging software (as she mentioned where she was) and by comparing the time logged on the screenshots with the student's timetable to determine whether the student was in a formal or informal learning setting. The following is an extract from the screenshots analysis forms (Appendix G) for the student's log files.

During a lecture	
13:25	Downloads 2 sets of lecture slides from the VLE (Biology and Physics).
During another lecture	
13:32	Views a set of lecture slides that were downloaded previously and takes notes (Physics).
14:06	Closes the slides file.
Break	
14:07	Opens the other set of slides (Biology).
14:20	Logs in the VLE, checks her email.
During a lecture	
14:35	Views the lecture slides and takes notes.
15:15	Closes the lecture slides file.
Break	
16:51	Views previous lecture slides (Biology) – revising.
16:53	Looks for word meaning using an online dictionary website.
17:07	Nothing – Screen saver on.
17:50	Chats with a colleague regarding a tutorial and that they need to revise the lecture slides to be able to meet with the group and solve the tutorial.
17:51	Revising the lecture slides to be able to solve a tutorial.
18:04	Copies a URL provided in the slides to the web browser and looks at the website. The site includes descriptions and animation in relation to the topic.
Home	
22:42	Changes the Internet connection setting. She is back home and connects to the home network. She logs in the VLE, and replies two messages sent to her through the VLE's chat room while she was away.
23:01	She replies to these messages. The messages are regarding the meeting discussed earlier. She proposes some topics for discussion in the meeting.
23:30	She continues revising the lecture slides and chats with the colleague about the meeting.
Next Day – During a group meeting that took place in a lecture theatre	

14:50	Opens yesterday's lecture slides (Biology) and goes through them.
16:41	Gets an online message from the student that she was chatting with yesterday regarding their meeting, apologises for being late and asks to see her in the canteen.
16:48	She gets back to the first slide and goes through them (started the meeting). At the same time she is checking her email and using an online dictionary.
18:30	Logs in MSN messenger.
18:34	Back to the slides.

This case, shown in Figure 7-1, represents a case of socially interesting mobile learning. The student's learning is considered mobile because she pursued learning activities that are directed towards the same learning objective (develop her understanding of a topic) in different physical locations such as the classroom and home. In addition, the student's learning in this case is socially interesting as the social context (rules and the division of labour of the community that share the object of the activity) of the learning activity changes as the student changes her location and the activity pursued. For example, when the student is in the classroom the rules and the division of labour that govern the community (shown in Figure 7-2) differ from those when the student is home and uses her laptop to revise the lecture slides and look for more information about the topic through the Internet (shown in Figure 7-3).

Figure 7-1 The case's interpretation using Activity Theory

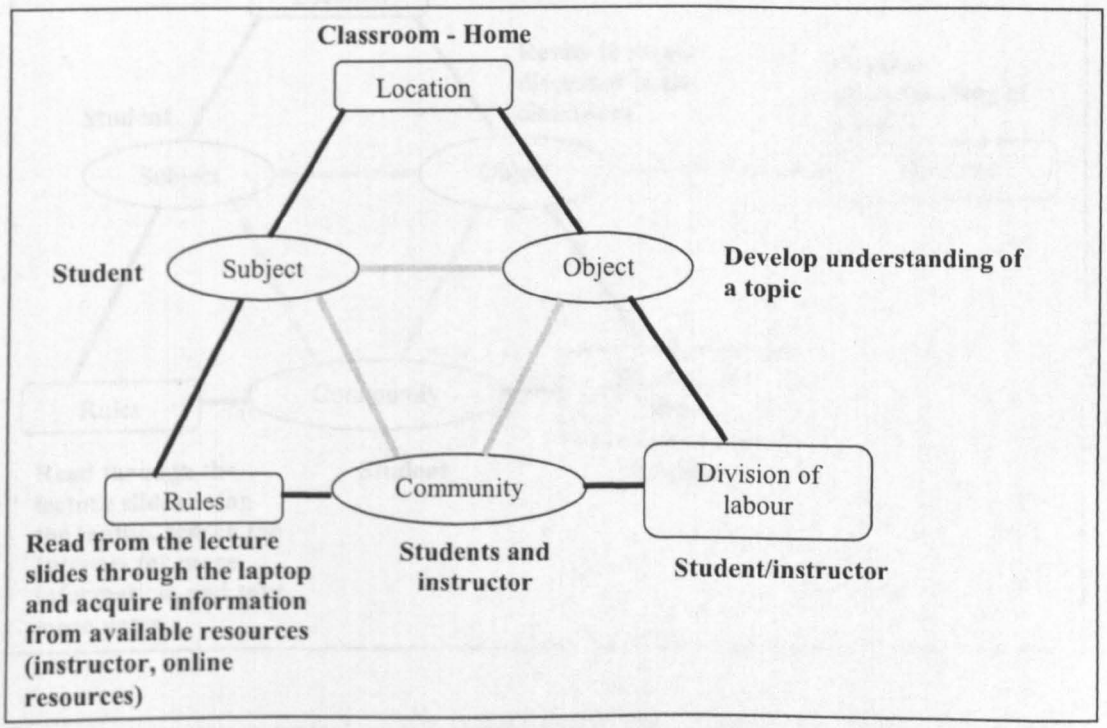


Figure 7-2 The case's interpretation using Activity Theory - Classroom

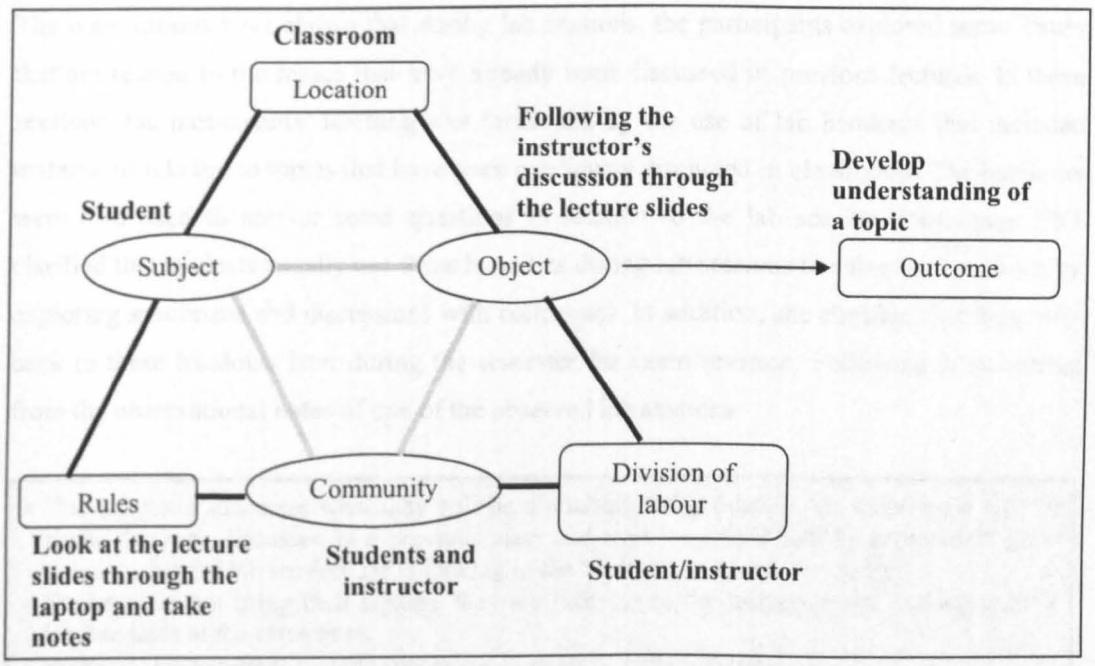
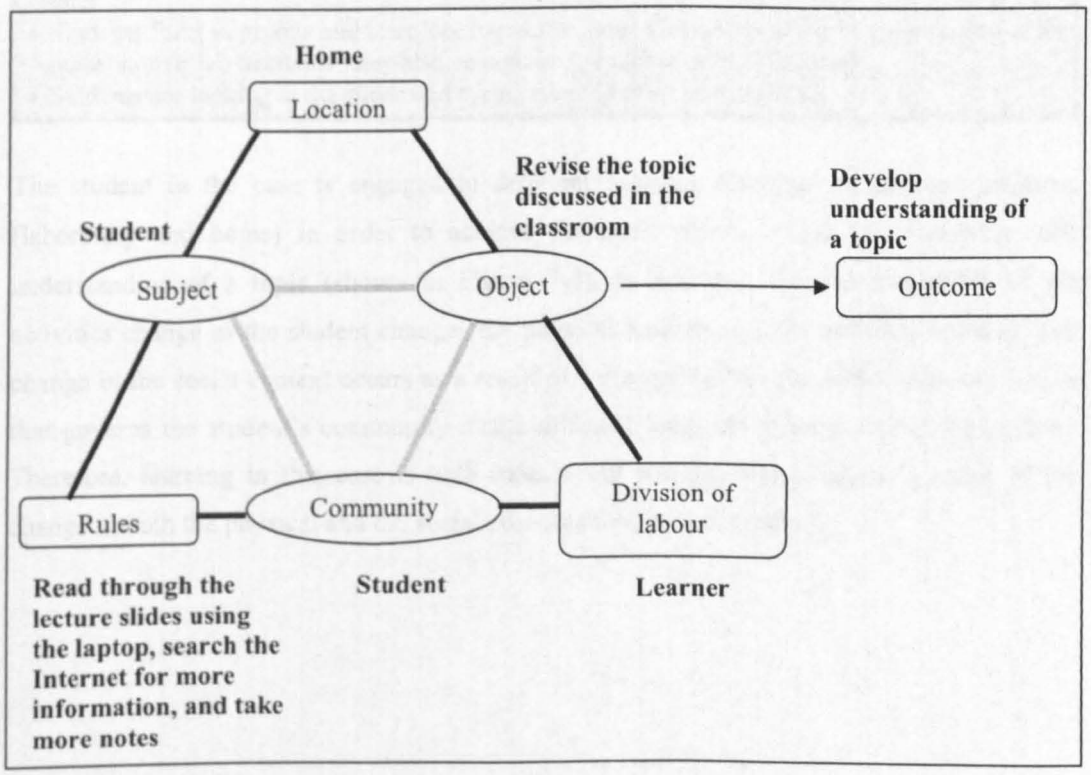


Figure 7-3 The case's interpretation using Activity Theory - Home



The case represents a typical socially interesting mobile learning case. Similar cases were found in many of the participants' log files where students engaged in learning activities in multiple formal and informal settings.

Conventional device

The observations have shown that during lab sessions, the participants explored some issues that are related to the topics that have already been discussed in previous lectures. In these sessions, the participants' learning was facilitated by the use of lab handouts that included material in relation to topics that have been previously discussed in classrooms. The handouts were also used to answer some questions in relation to the lab session. Participant FY1 clarified that students usually use these handouts during lab sessions to solve the questions by exploring specimens and discussions with colleagues. In addition, she clarified that they refer back to these handouts later during the semester for exam revision. Following is an extract from the observational notes of one of the observed lab sessions.

- The instructor discusses what they will be discussing today (slides). He mentions a type of tissue that was discussed in a previous class and explains that it will be explored in great detail during the lab session. He is looking in the lab handout and so do students.
- Students are not using their laptops, they are listening to the instructor and looking at their lab handouts at the same time.
- Students' lab handouts include spaces for students to write and draw.
- The instructor asks students to start working on the lab exercise which is looking at some slides using a microscope and mentions that he will illustrate the other part of the lab sheet later.
- Students form in groups and start looking at the tissue slides through a microscope and write notes in their lab handouts, they also engage in discussions about the slides.
- Students are looking at the slides and taking notes in their lab handouts.

The student in the case is engaged in different learning activities in different locations (laboratory and home) in order to achieve the same object, which is developing their understanding of a topic (shown in Figure 7-4). In addition, the social contexts of the activities change as the student changes the physical location and the activities pursued. The change in the social context occurs as a result of a change in the rules and division of labour that governs the student's community in the different locations (Figure 7-5and Figure 7-6). Therefore, learning in this case is both mobile and socially interesting as a result of the change in both the physical and the social context of the learning activity.

Figure 7-4 The case's interpretation using activity theory

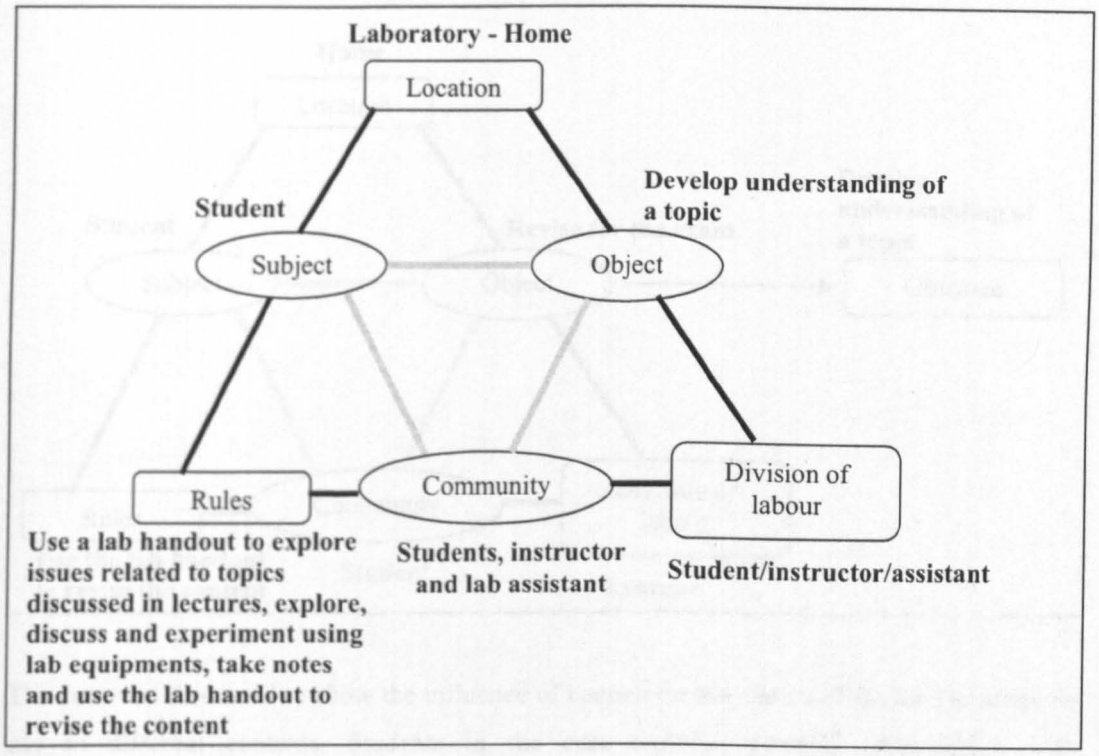


Figure 7-5 The case's interpretation using Activity Theory - Laboratory

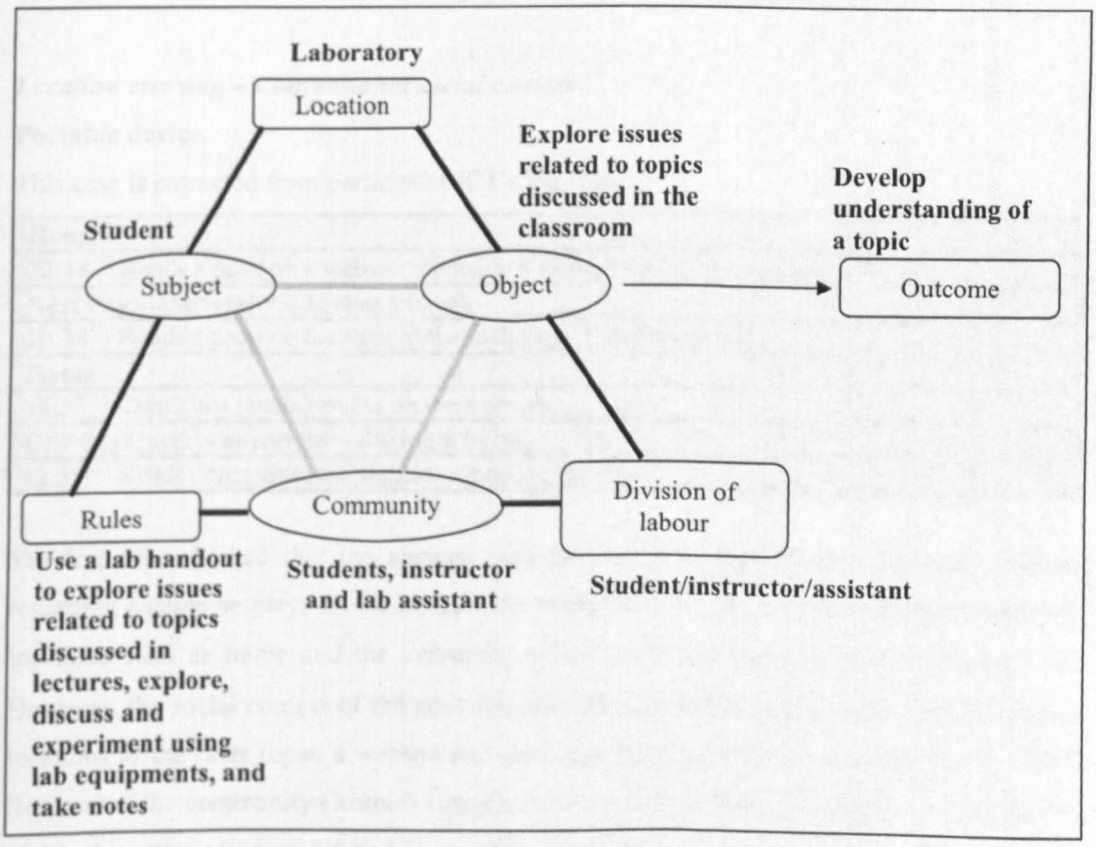
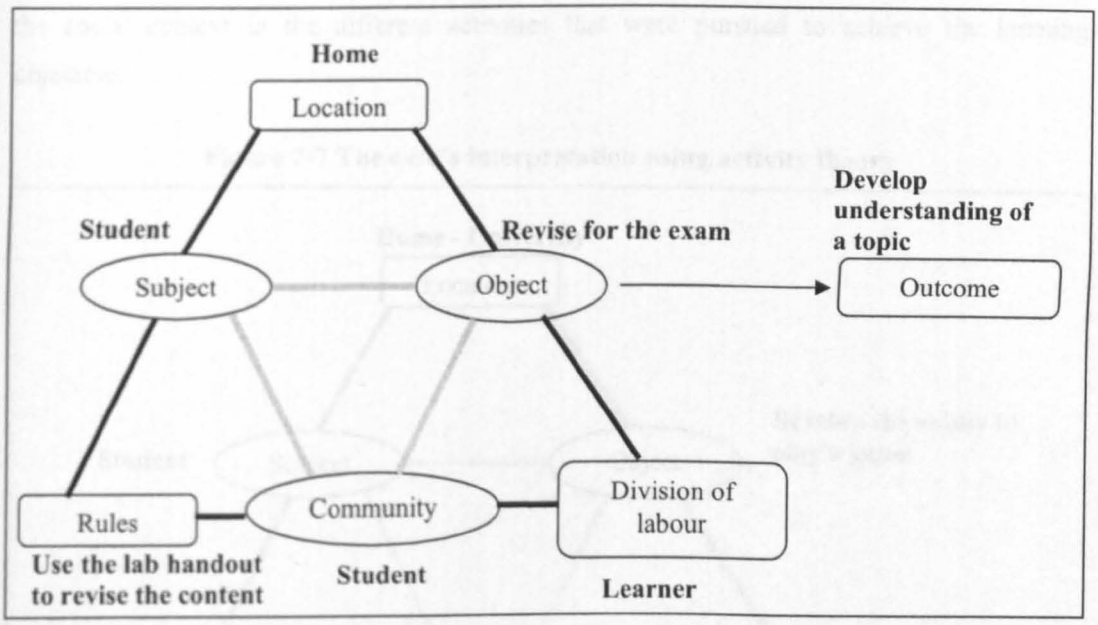


Figure 7-6 The case's interpretation using Activity Theory - Home



The case was discussed to show the influence of context on the choice of device that students use in different contexts. Students in the case replaced portable technologies with conventional ones in contexts where the use of portables is difficult. The case also shows that students' choice of device is affected by the instructor's expectation of students.

Location crossing – Conventional social context

Portable device

This case is extracted from participant JC1's log files.

Home
22:48 Reads a page on a website related to a game installed in his laptop.
Next day – University –During a break
10:38 Reads a page on the same website through the same game.
Home
15:57 Continues reading pages on the website.
Few days later – university - during a break
12:17 Reads pages from the website regarding the game.

The log files showed that the student used his laptop to read from a discussion forum regarding a game he plays on his laptop. The student visited the website in different physical locations such as home and the university which made his learning mobile (Figure 7-7). However, the social context of the activities that the student pursued did not change in these locations as the rules (open a website and read regarding a game) and the division of labour (learner) of the community (learner) engaged in the activity remain unchanged in the different physical locations (Figure 7-8 and Figure 7-9). Therefore, the student's learning in this case is

classified as mobile learning but learning is not socially interesting because of the stability of the social context in the different activities that were pursued to achieve the learning objective.

Figure 7-7 The case's interpretation using activity theory

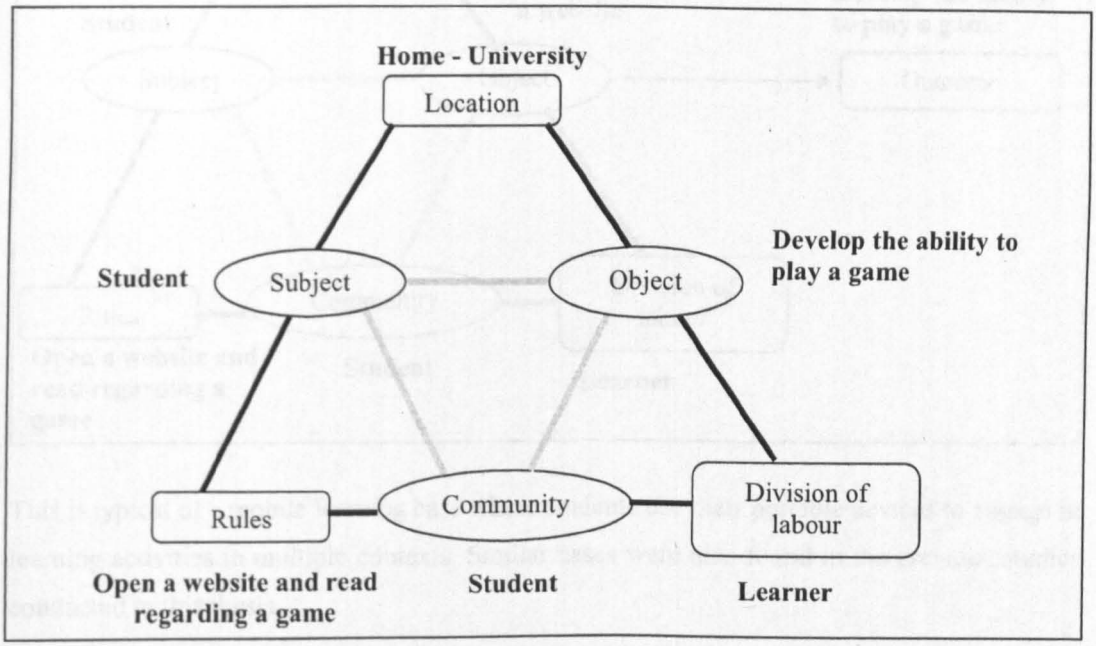


Figure 7-8 The case's interpretation using activity theory- Home

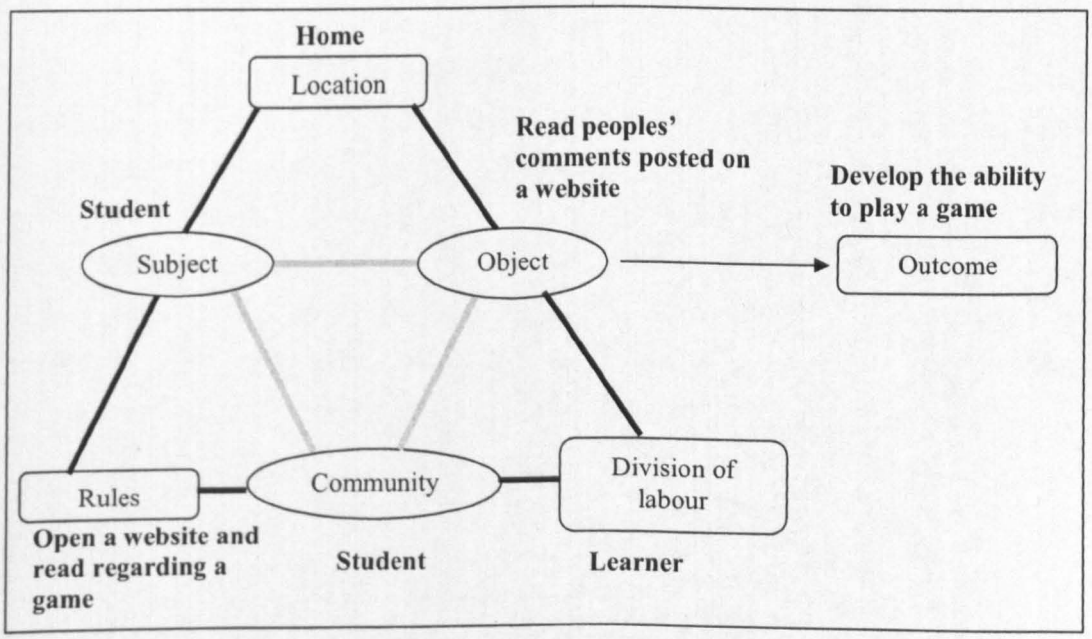
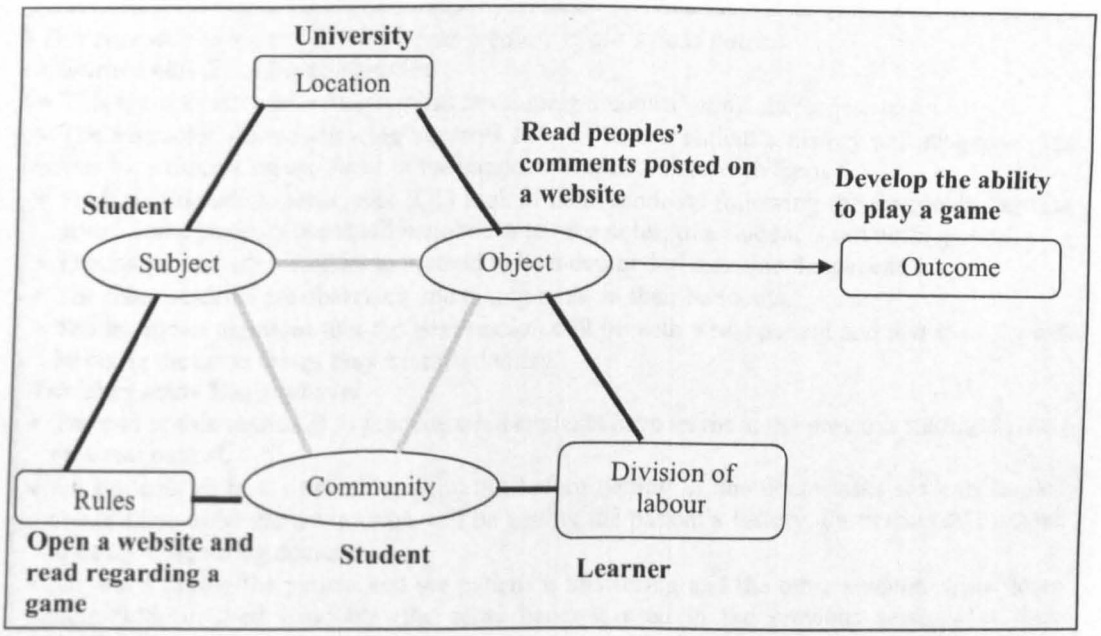


Figure 7-9 The case's interpretation using activity theory - University



This is typical of a mobile learning case where students use their portable devices to engage in learning activities in multiple contexts. Similar cases were also found in the previous studies conducted in this thesis.

Conventional device

This case was extracted from the intermediate cycle's field notes.

Clinical Skills Examination session

- This is a tutorial session that aims at developing students' clinical competences.
- The instructor started showing students how to take a patient's history and diagnose. The points he is discussing are listed in the handouts students have with them.
- Students (including participant IC1) look at their handouts following the instructor and take notes. Some students use small handbooks to take notes, one student is not writing at all.
- The instructor asks a student to pretend to be a doctor and examine the patient.
- The other students are observing and taking notes in their handouts.
- The instructor mentions that the next session will be with a real patient and that students will be doing the same things they exercised today.

Two days later- Ward tutorial

- The aim of this session is to practice what students have learnt in the previous tutorial session on a real patient.
- All students go to the patient's room, but before getting in, the doctor asks students to pick one of them to be the doctor who will be getting the patient's history. Participant IC1 agreed to be the diagnosing doctor.
- IC1 starts asking the patient and the patient is answering and the other students write down their notes in their handouts (the same handout used in the previous session) or their handbooks.
- The participant was referring to his handout to make sure of the sequence of questions he is asking.

Five days later - Clinical Skills Examination session

- The tutorial is in a seminar room, unlike last week where it was in an examination room.
- During the session, students (including participant IC1) are using their handouts to refer to some points that help them diagnose the pretending patient. They are writing down some notes as well.

The observations have shown that the participant's (IC1) learning is mobile as he used a handout to aid his learning about a specific topic in different learning settings that took place in different physical locations such as an examination room, a patient's room and a tutorial room (shown in Figure 7-10). The student's learning in all these physical locations was aimed at one objective which is to understand the way he should approach patients, take their medical history and diagnose them. The social contexts of diagnosing patients in the different settings did not change by the change of the location or the activity. This is because of the stability of the rules and division of labour of the community engaged in the activity (Figure 7-11, Figure 7-12 and Figure 7-13). Thus, learning in this case is not socially interesting.

Figure 7-10 The case's interpretation using Activity Theory

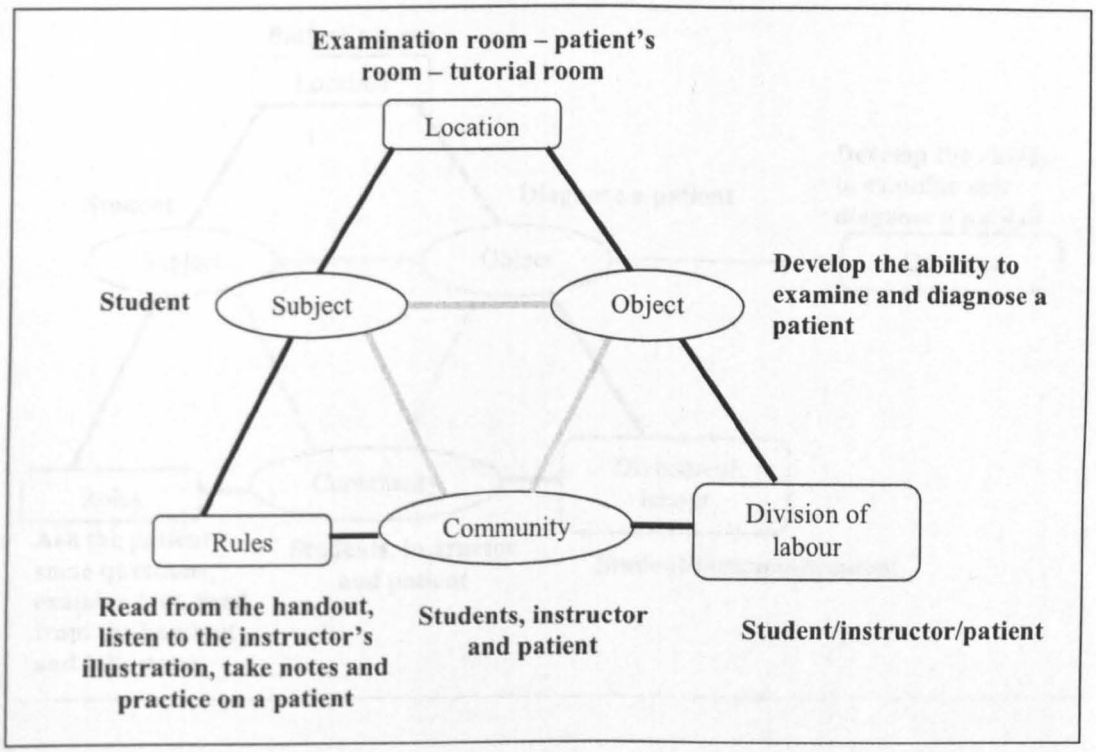


Figure 7-11 The case's interpretation using Activity Theory – Examination room

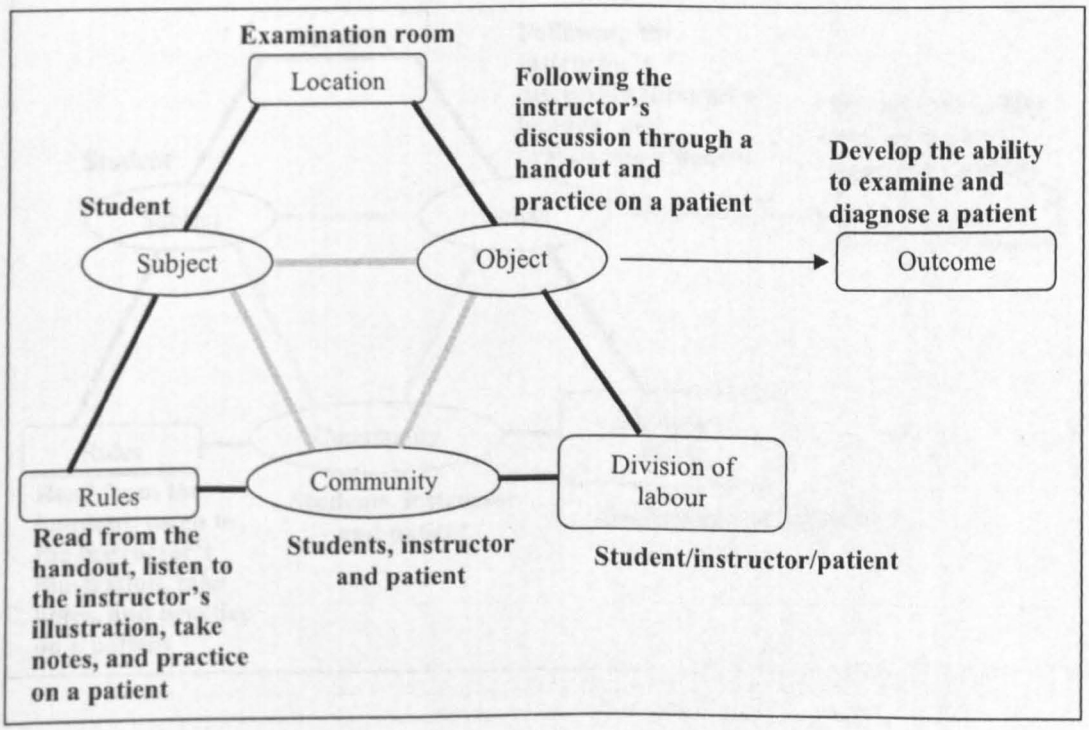


Figure 7-12 The case's interpretation using Activity Theory – Patient's room

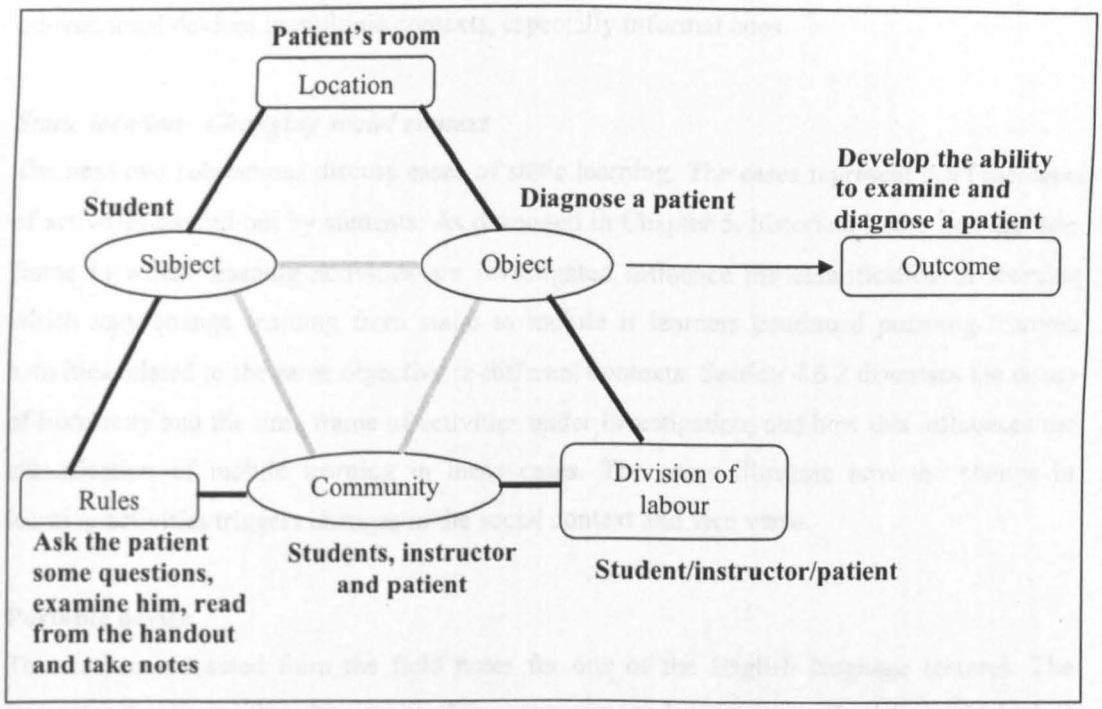
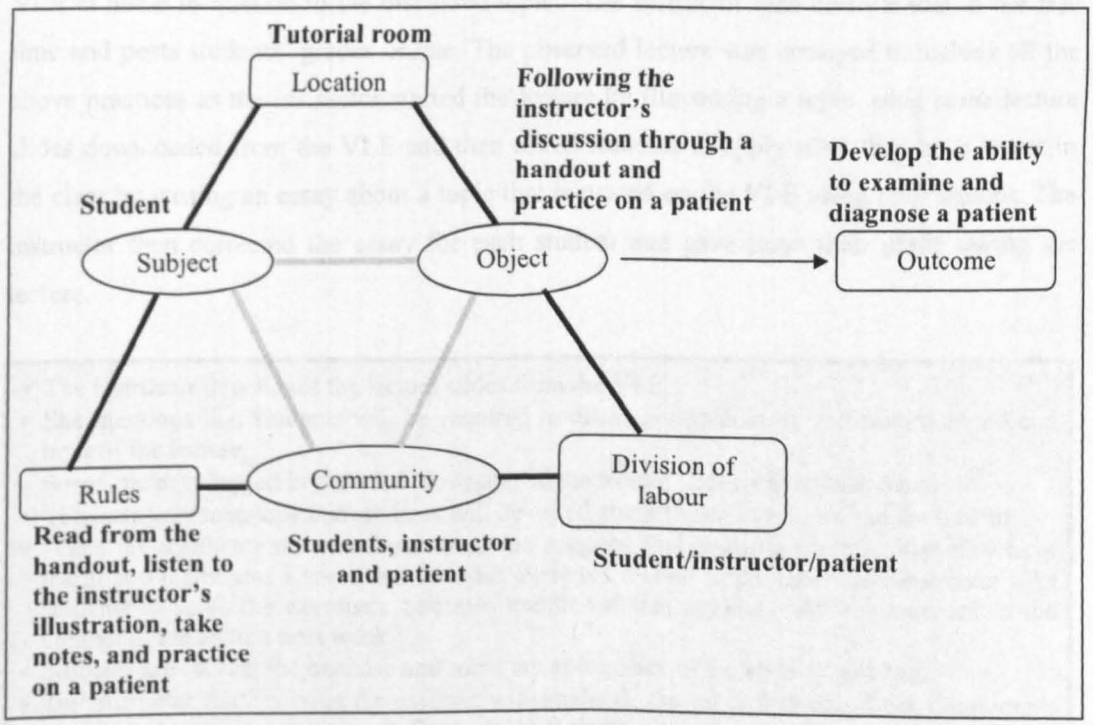


Figure 7-13 The case's interpretation using Activity Theory – Tutorial room



This case was discussed to show how students use conventional devices to facilitate their learning activities across multiple contexts. Not many similar cases were found in this study

because of limited data (especially observations) that reflects on students' utilisation of conventional devices in multiple contexts, especially informal ones.

Static location– Changing social context

The next two subsections discuss cases of static learning. The cases represent brief incidents of activities carried out by students. As discussed in Chapter 5, historical issues and the time frame in which learning activities are investigated influence the classification of learning which may change learning from static to mobile if learners continued pursuing learning activities related to the same objective in different contexts. Section 7.6.2 discusses the issues of historicity and the time frame of activities under investigation, and how this influences the classification of mobile learning in these cases. The cases illustrate how the change in learning activities triggers changes in the social context and vice versa.

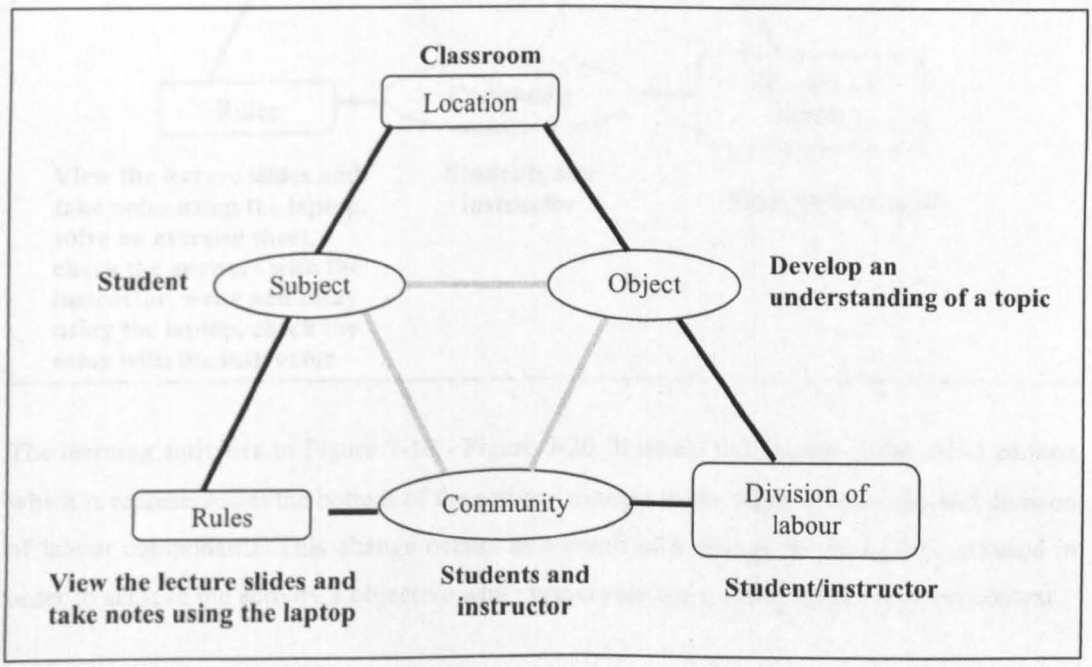
Portable device

This case is extracted from the field notes for one of the English language lectures. The instructor mentioned that she aims to change the way the lecture is usually delivered which is based on illustration through slides and then asking students to write an essay posted on the VLE at home in relation to the discussed topic. The instructor then corrects that in her free time and posts students' grades online. The observed lecture was arranged to include all the above practices as the instructor started the lecture by illustrating a topic using some lecture slides downloaded from the VLE and then asked students to apply what they have learnt in the class by writing an essay about a topic that is posted on the VLE using their laptops. The instructor then corrected the essay for each student and gave them their grade during the lecture.

- The instructor downloads the lecture slides from the VLE.
- She mentions that students will be required to do an assignment by the end of the second hour of the lecture.
- Some students logged in the VLE, downloaded the lecture slides and opened them.
- The instructor mentions that students will be asked about today's topic later in the lecture.
- When the instructor finishes illustrating, she suggests that students practice what they have learnt and distributes a sheet that includes exercises related to the topic. The instructor asks students to solve the exercises. She also mentioned that students will be examined in the content of the lecture next week.
- Students are solving the exercise and some are going back to the slides to get help.
- The instructor starts solving the exercise with students, she reads from the sheet, the students answer and instructor validates it. Students write down the correct answer.
- After solving the exercise, the instructor asks students to write an essay about to the topic that is posted on the VLE. The instructor mentions that she will correct the essay during the class.
- Students are logging in to the VLE, downloading the assignment sheet, some are discussing it and others are writing the essay.

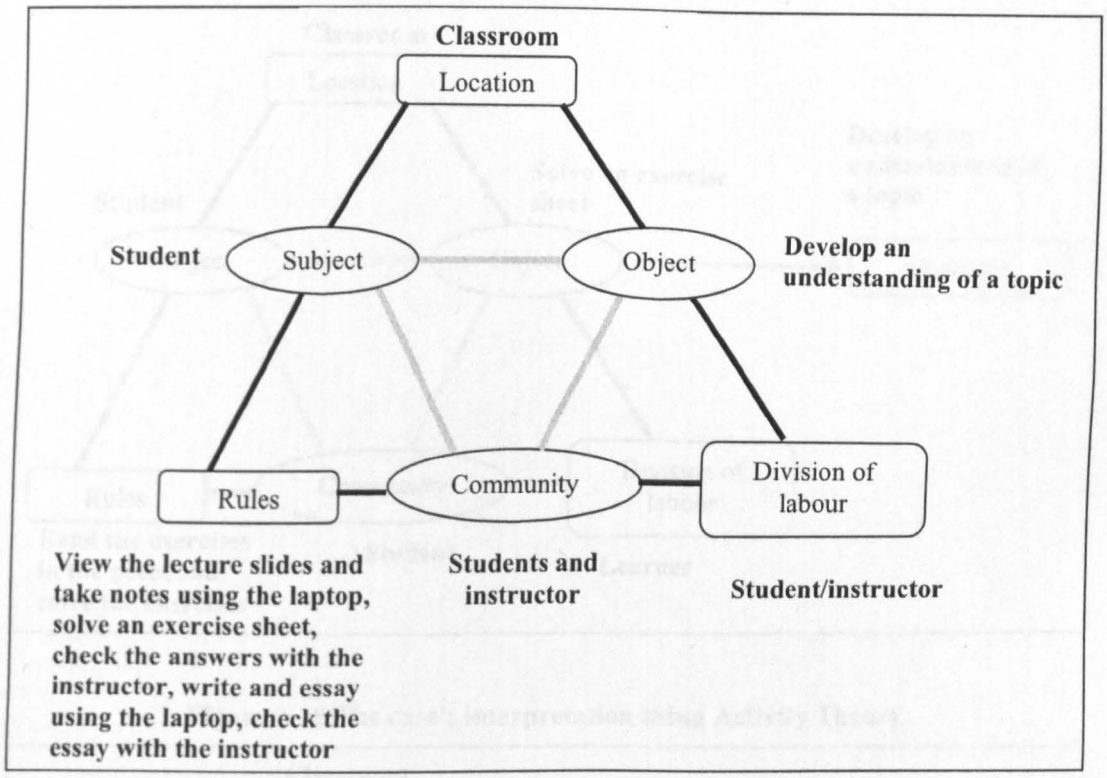
This example represents a socially interesting static learning case as the objective of the learning activity was achieved while students are still in the same physical location which is the classroom. The case is socially interesting because of the changes in the social context of the learning activities that took place during the lecture which is different from these for the previous lectures. This is represented in the rules, community and the division of labour components. Figure 7-14 shows the activity system for students' learning activities that usually take place inside the classroom.

Figure 7-14 The case's interpretation using Activity Theory



The figure below represents the activity system of the observed lecture where the instructor altered the setting from the previous lectures. The figure shows the changes in the social context.

Figure 7-15 The case's interpretation using Activity Theory



The learning activities in Figure 7-16 - Figure 7-20 illustrate the change in the social context which is represented at the bottom of the activity triangle in the rules, community and division of labour components. This change occurs as a result of a change in the activity pursued in order to achieve the activity's objective while preserving the stability of the physical context.

Figure 7-16 The case's interpretation using Activity Theory

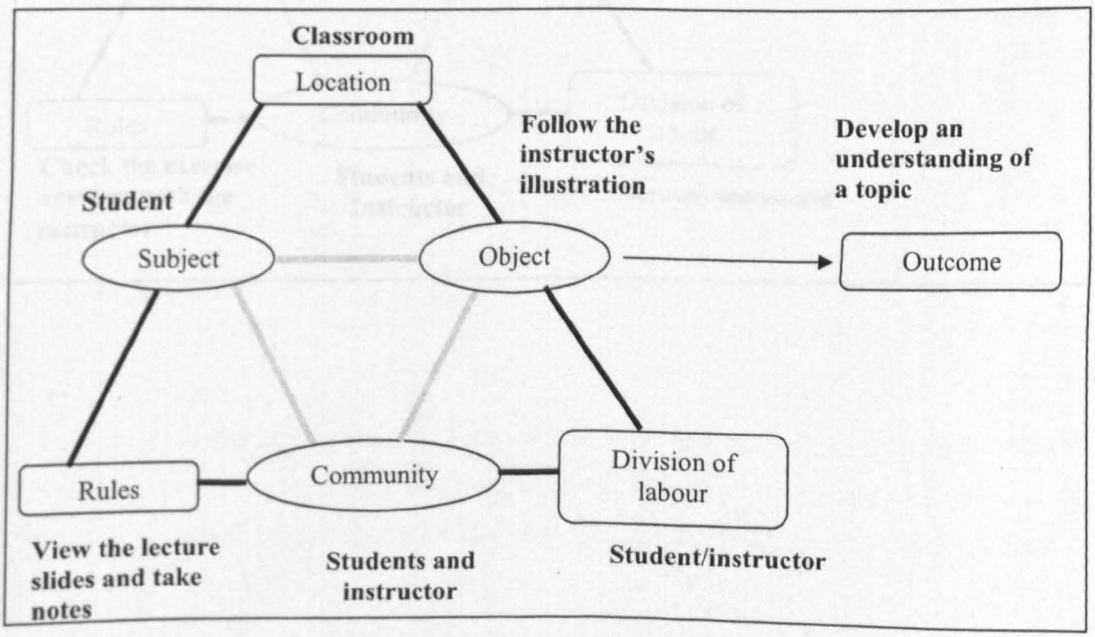


Figure 7-17 The case's interpretation using Activity Theory

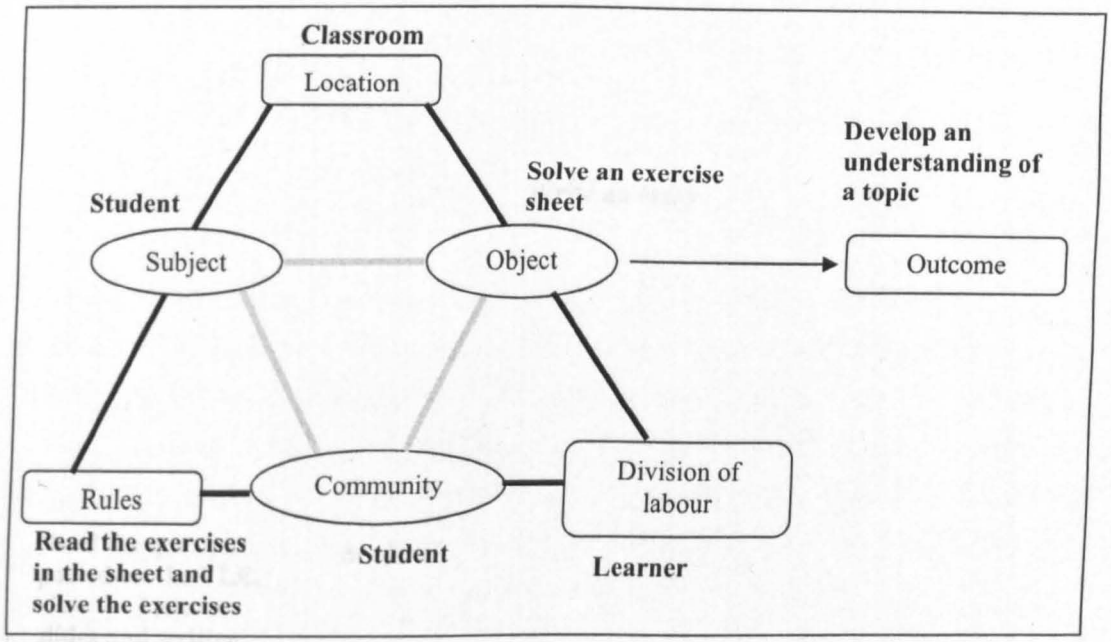


Figure 7-18 The case's interpretation using Activity Theory

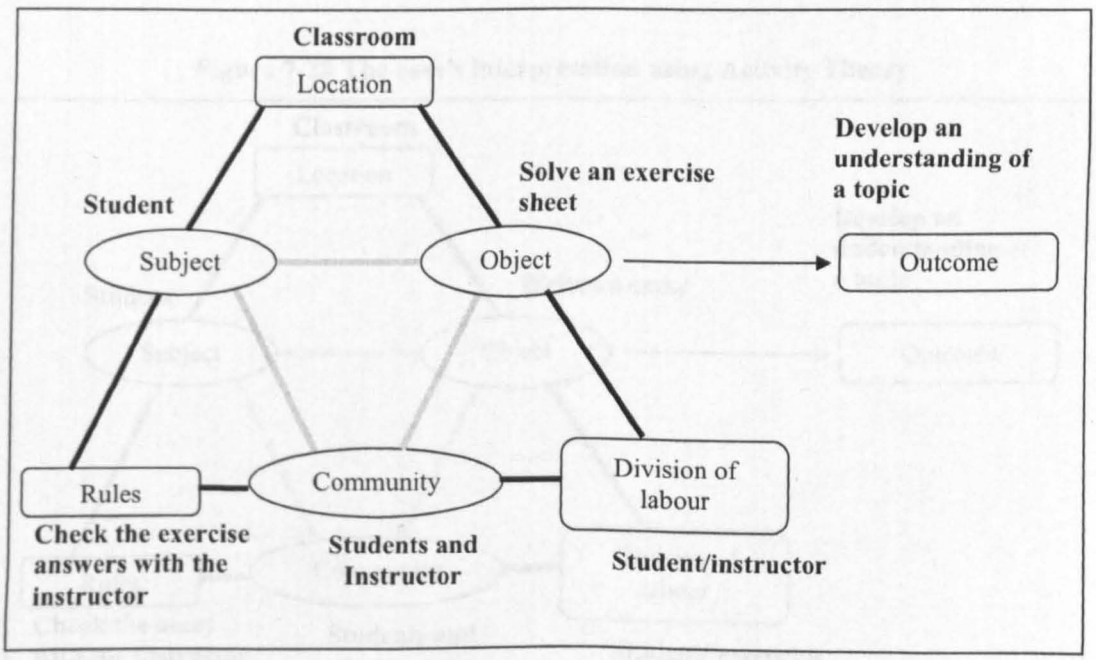


Figure 7-19 The case's interpretation using Activity Theory

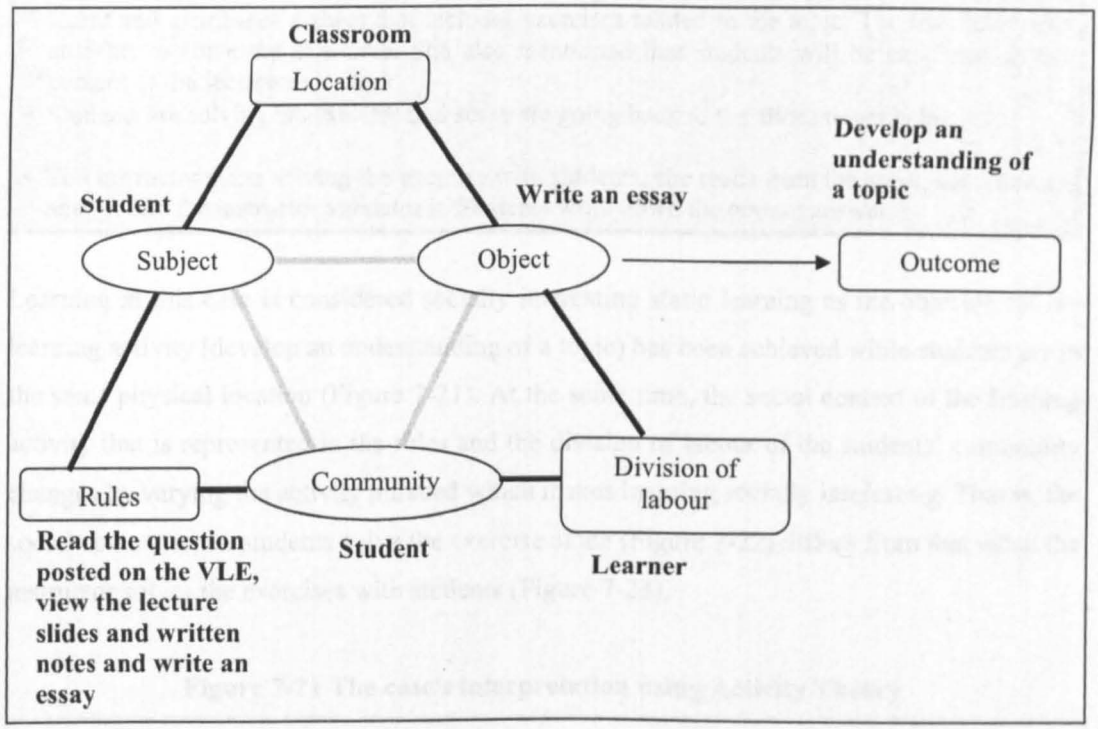
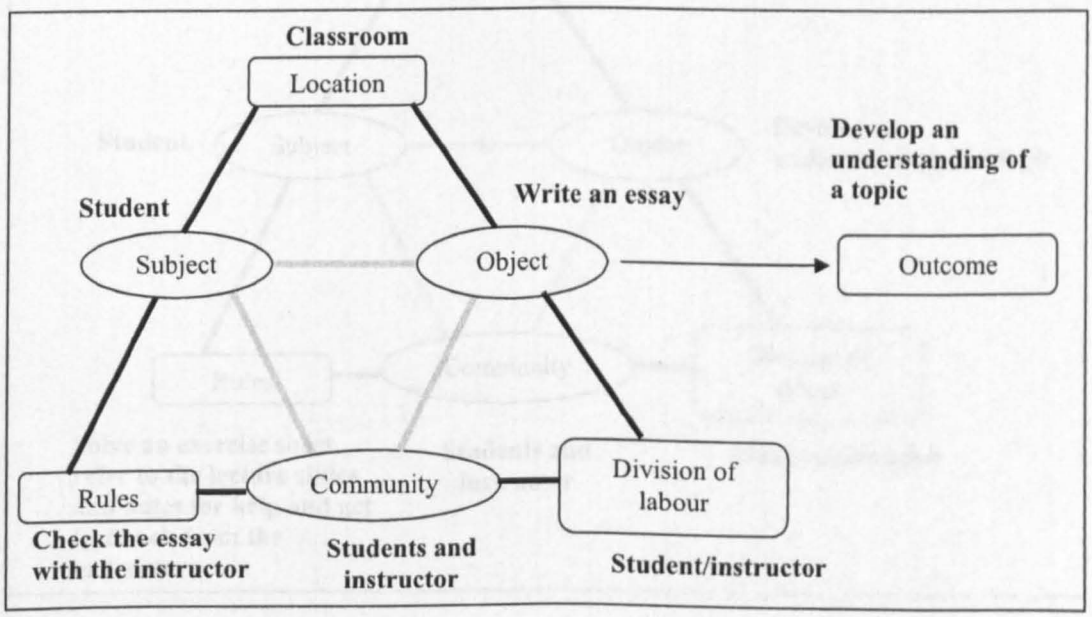


Figure 7-20 The case's interpretation using Activity Theory



Conventional device

This example is extracted from the field notes for the English language lecture discussed above. The instructor distributed a set of exercises sheets for students to solve during the class. The instructor asked students to solve the exercise on their own and then she solved it with the rest of the class.

- When the instructor finishes illustrating, she suggests that students practice what they have learnt and distributes a sheet that includes exercises related to the topic. The instructor asks students to solve the exercises. She also mentioned that students will be examined in the content of the lecture next week.
- Students are solving the exercise and some are going back to the slides to get help.

...

- The instructor starts solving the exercise with students, she reads from the sheet, the students answer and the instructor validates it. Students write down the correct answer.

Learning in this case is considered socially interesting static learning as the objective of the learning activity (develop an understanding of a topic) has been achieved while students are in the same physical location (Figure 7-21). At the same time, the social context of the learning activity that is represented in the rules and the division of labour of the students' community changes by varying the activity pursued which makes learning socially interesting. That is, the social context when students solve the exercise alone (Figure 7-22) differs from that when the instructor solves the exercises with students (Figure 7-23).

Figure 7-21 The case's interpretation using Activity Theory

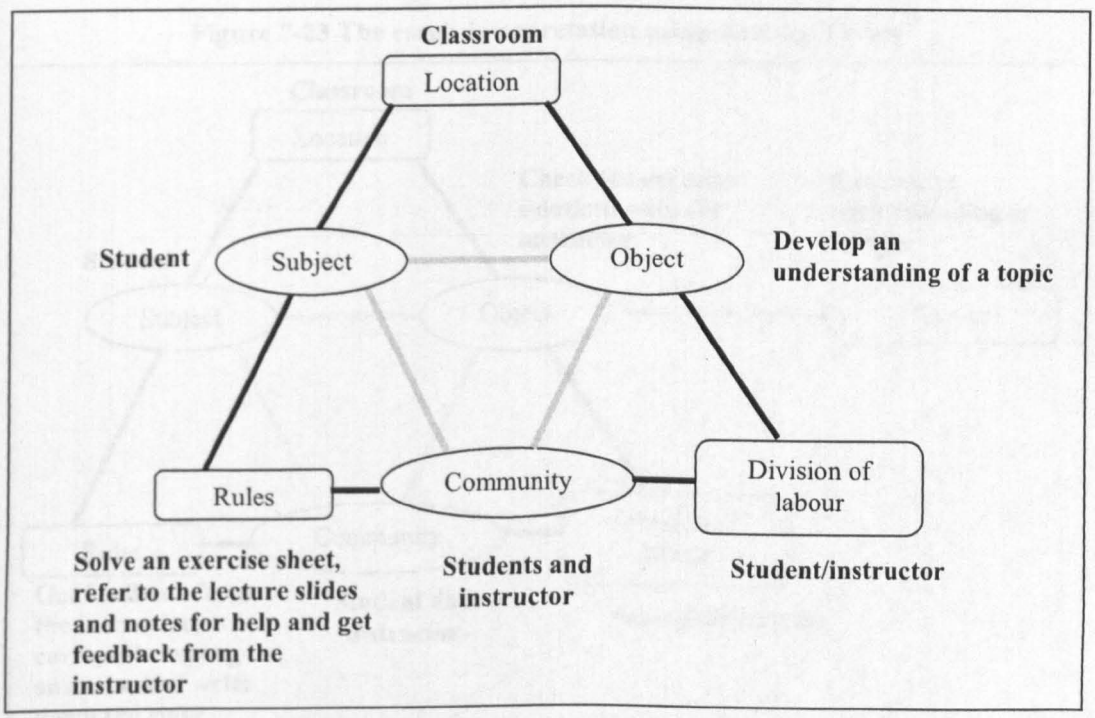


Figure 7-22 The case's interpretation using Activity Theory

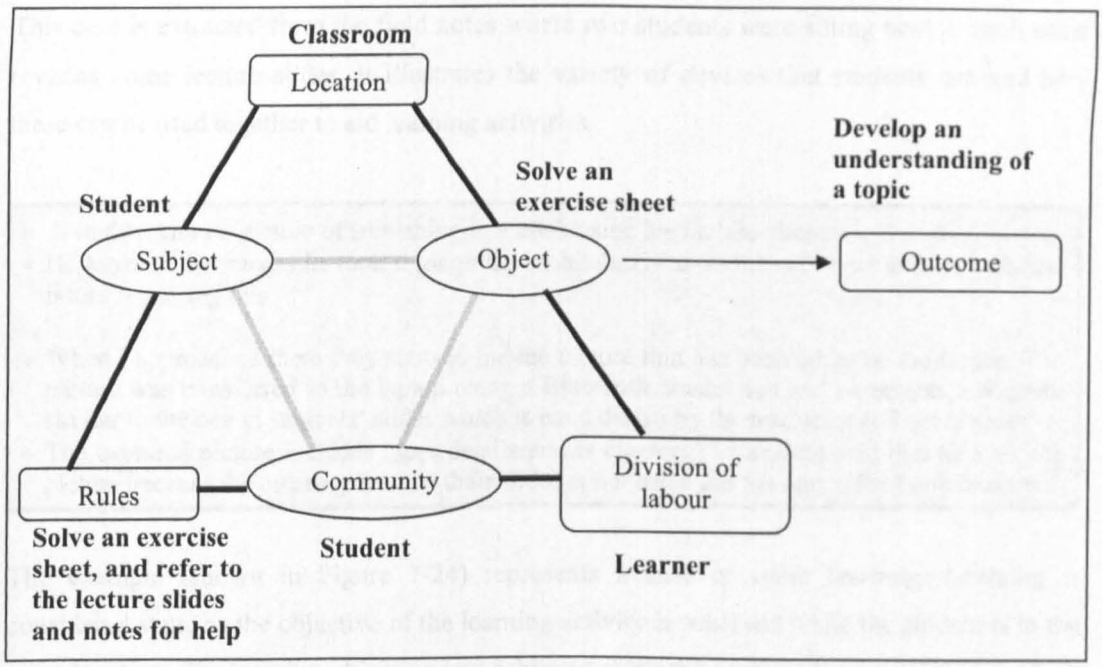
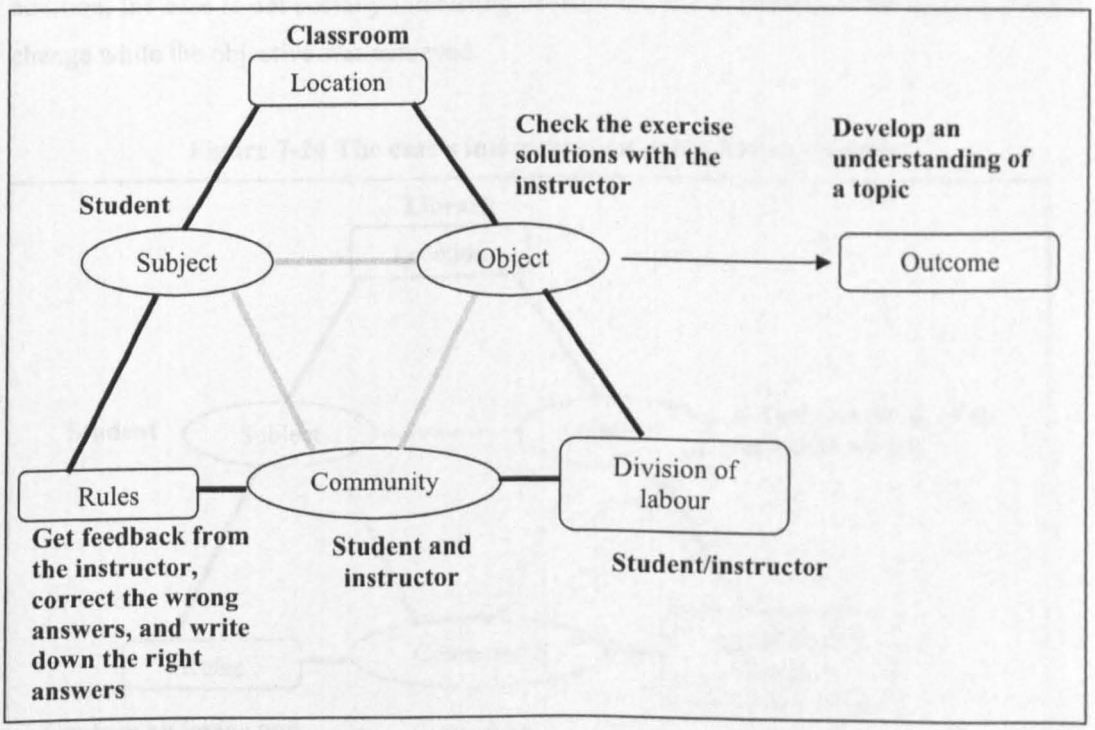


Figure 7-23 The case's interpretation using Activity Theory



Static location – Conventional social context

The two examples discussed here are typical cases of static learning and conventional social context. Similar cases were found in this study and the studies discussed in Chapter 4 and Chapter 5.

Portable device

This case is extracted from the field notes where two students were sitting next to each other revising some lecture slides. It illustrates the variety of devices that students use and how these can be used together to aid learning activities.

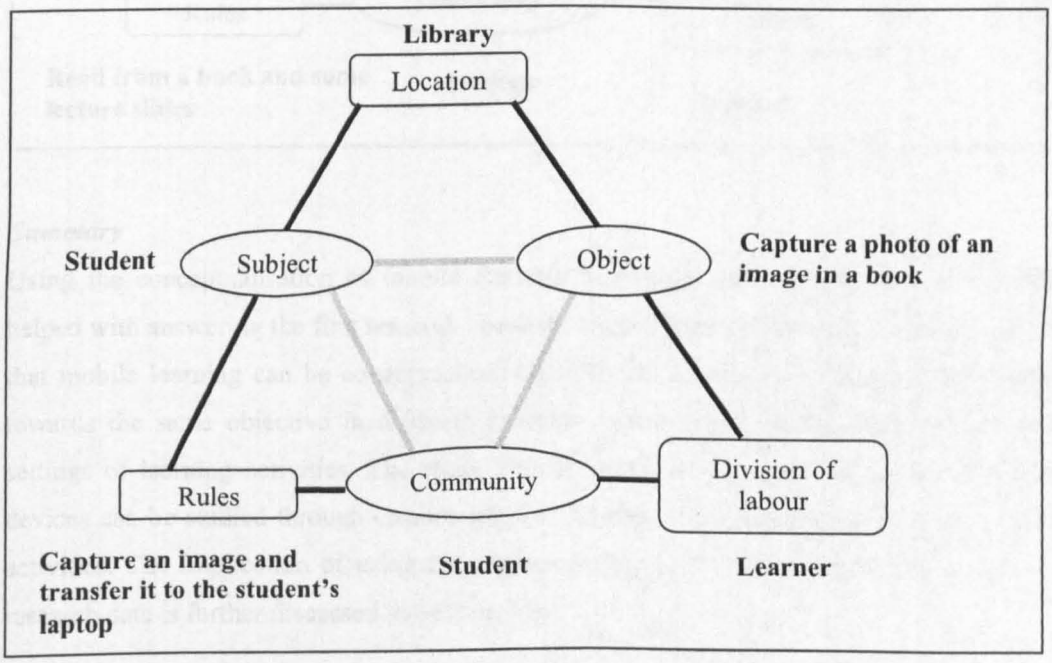
- A student takes a picture of something in a book using his mobile phone.
- He looks at the images he took through the mobile and shows his colleague and they discuss issues regarding this.

...

- When I approached them they showed me the picture that has been taken on the laptop. The picture was transferred to the laptop using a Bluetooth connection and represents a diagram similar to the one in students' slides which is hand drawn by the instructor and is not clear.
- The captured picture includes more details and is clearer. The student said that he took the picture because the one they have in their slides is not clear and the one in the book is better.

The example (shown in Figure 7-24) represents a case of static learning. Learning is considered static as the objective of the learning activity is achieved while the student is in the same location. The learning objective was achieved using the mobile phone to capture a photo for an image in a book and transferring it to his laptop to help with the slides revision. In addition, the case is not socially interesting because the social context of the activity did not change while the objective was achieved.

Figure 7-24 The case's interpretation using Activity Theory



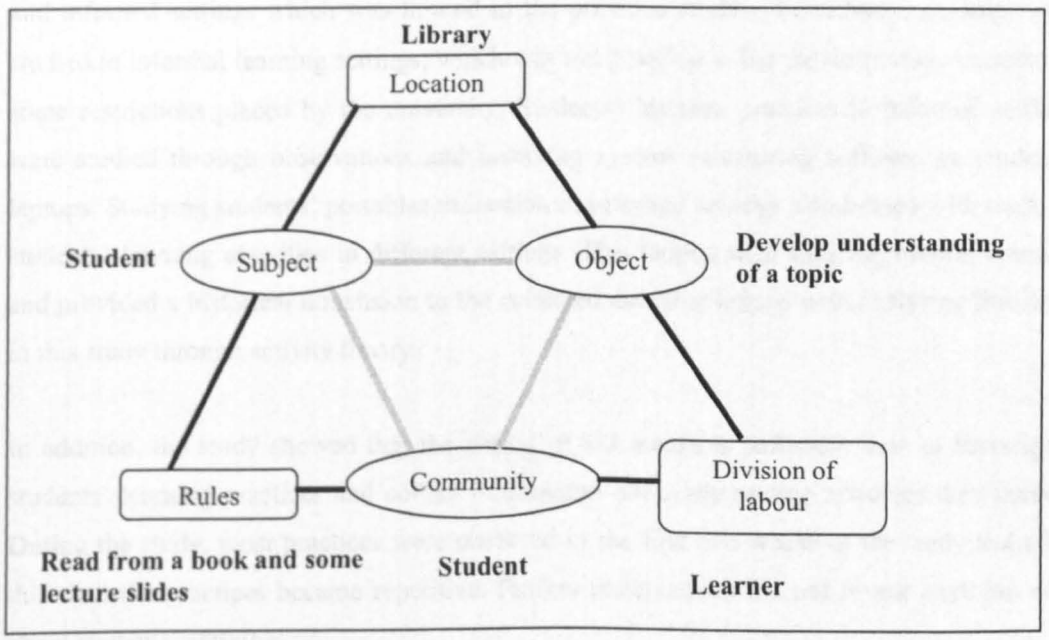
Conventional device

The case was also extracted from the field notes for the library observations.

A student is using a book that she has taken from the library shelves. And at the same time, the student is looking at her laptop and going through some slides. Before leaving the library, the student returns the book to the shelves.

Learning in this case (shown in Figure 7-25) is static because the objective of the activity, reading from a book to aid learning about an issue, was achieved while the student is still in the same physical context. In addition, no changes have occurred in the social context of the activity while the objective was achieved. Therefore, learning in this case is considered static and is not socially interesting.

Figure 7-25 The case's interpretation using Activity Theory



Summary

Using the conceptualisation of mobile learning to analyse the research data in this study helped with answering the first research question: What is mobile learning? The study showed that mobile learning can be conceptualised by studying learning activities that are directed towards the same objective in different contexts considering both the physical and social settings of learning activities. The study also showed that the innovative uses of portable devices can be studied through considering the changes in the social context of the learning activities. The implication of using the conceptualisation of mobile learning to analyse the research data is further discussed in Section 7.6.2.

7.6 Discussion

This section discusses what the analysis revealed about the modifications that were proposed in the previous chapter in response to the limitations found in the study design and data analysis and were implemented in this study.

7.6.1 Methodological issues

The study discussed in this chapter implemented the changes proposed in the previous chapter regarding the sample studied. It focused on studying a small number of cases instead of whole classes as in the previous studies in this thesis. This helped with providing more detailed information about students' learning practices and the utilisation of portables in both formal and informal settings which was limited in the previous studies. In addition, students were studied in informal learning settings, which was not possible in the previous study because of some restrictions placed by the university. Students' learning practices in informal settings were studied through observations and installing system monitoring software on students' laptops. Studying students' portables utilisation in informal settings also helped with tracking students' learning activities in different settings. This helped with studying mobile learning and provided a historical dimension to the collected data that helped with analysing the cases in this study through activity theory.

In addition, the study showed that the period of 2-3 weeks is sufficient time to investigate students' learning practices and collect information about the routine activities they pursue. During the study, most practices were observed in the first two weeks of the study and after this time the practices became repetitive. Further observations did not reveal anything new about students' activities.

Furthermore, in this study, first year students were studied to represent students with less expertise using portables. This helped with answering the first focus question about the differences between students' utilisation of portables when these are supplied as part of a study and when these are used to accomplish routine study practices which could not be explored thoroughly in the previous two studies.

7.6.2 Analytical issues

The conceptualisation of mobile learning that was introduced in the previous chapter was used to analyse the research data and understand mobile learning in this chapter. Mobile learning was defined as learning across contexts where context is understood as encompassing both the social and physical setting of learning activities. Using the new conception of mobile learning and the classifications in Table 7-2 to analyse the research data in this chapter helped

to validate the new conception of mobile learning and differentiate mobile and static learning. Examples of the different types of learning that were proposed (based on the change in context as the physical and social) were found in the research data for both old and new technologies. This shows that the proposed conceptualisation of mobile learning can be used to study real-world cases, and is not limited to learning that is mediated by the use of new portable technologies, which was a limitation of some of the current definitions of the term in the literature.

Using the conceptualisation of mobile learning also helped with differentiating mobile learning from static learning. However, the cases of static learning identified in this chapter present brief incidents of activities which, if continued in a different context, will cause learning to be classified as mobile. This is affected by the time frame in which activities are studied. The longer the time that students' learning activities are studied, the greater the chance to observe related activities, which would result in students' learning being classified as mobile. It is worth clarifying that the focus of the analysis of learning in the case studies in this thesis has been on whether particular instances of learning practices that are represented in the data collected in the studies are mobile or static; the focus is not on all learning. If the focus was to be on students' learning practices over long time periods, and since the conceptualisation of mobile learning in this thesis links to the learner being mobile, learning will inevitably be mobile in all cases because of the mobility of the learner who carries out learning activities in different locations over time. In addition, as presented in Table 7-2, focusing on particular instances of learning activities enables focusing on interesting and timely practices which otherwise would not be recognised. This arises particularly in the 'socially interesting mobile learning' cell in the table which enables a focus on mobile learning and at the same time highlights what is socially interesting about the case.

In addition, using the conception of context as both the physical and social setting of learning activities provided an insight into the innovative uses of portables for learning which was not found in the previous chapters. The innovative usage of portables for learning was determined by a change in the social context of the learning activity which is represented in an activity system as the rules and division of labour of the community engaged in the object of the activity. This answers a question that was raised in the previous chapter about whether innovative usage of portables could not be found due to the limitations of the previous studies or if it was not there to be found. This chapter has shown that innovative practices can be identified using this method, suggesting that innovation was probably absent from the previous cases.

Therefore, the conceptualisation of mobile learning gave a new perspective on the term through re-thinking it in terms of context crossing where the focus shifted from the technology used, as in some current definitions, to changes in the context of use.

7.7 Conclusions

This chapter has described a study that aimed at investigating the research questions in ways that were not possible in the previous two studies conducted in this thesis. The study revealed that studying a small number of students enabled getting in-depth data about their utilisation of portables to accomplish learning practices in both formal and informal settings and studying mobile learning. In addition, the study helped with validating the conception of mobile learning that was introduced in the previous chapter which was built on studying students' learning activities in different contexts through activity theory and considering context as both the physical and social contexts of learning activities. Moreover, the study helped with answering the research questions and exploring some of the issues that could not be studied in the previous studies due to the shortcomings of the studies' data collection and analysis methods. The next chapter provides a summary of this thesis, discusses its main contributions and limitations and overviews possible directions for further research.

Chapter 8
Conclusion

This chapter concludes this thesis by reviewing its purpose and summarising the findings of the three studies conducted. The chapter also outlines the main contributions of the research, discusses its limitations, summaries the issues raised that are worthy of further investigation, and outlines its implications for educational policy and practice.

8.1 Reviewing the purpose of the thesis

The main aim of this thesis was to develop a theoretical foundation for the term 'mobile learning' based on empirical studies. This included investigating students' utilisation of portable devices to accomplish their routine study practices in multiple contexts. This thesis also studied the relationship between context and students' practices considering context as a factor that influences and is influenced by learning activities. Context was considered as the combination of the physical and the social setting of learning activities. To examine these issues, three studies were conducted in two higher education institutions with different settings. Two studies were conducted in a university in Bahrain. The university implements a campus wide laptop program by providing all students and academic staff with laptops to be used to accomplish their routine tasks. The other study was conducted in a university in the UK that did not implement such a program. The studies used both qualitative (questionnaires, observations, log files, interviews) and quantitative (questionnaires) data collection methods. However, the studies relied more on qualitative data sources for the majority of the findings. Each study helped with developing the understanding of the main issues of concern to this thesis which cumulatively answered the research questions.

In this thesis, the understanding of the concept 'mobile learning' and the relationship between that and context was developed in the first study. Context was conceptualised as the combination of the physical and social setting of learning activities. This helped with considering the collective context that affects and is affected by learning activities. A re-conceptualisation of mobile learning was presented in the second study based on the idea of context-crossing through activity theory. Then, the conception of mobile learning was applied to the third study's data which helped with validating it. The key outcomes of the research are discussed in the next section.

8.2 Synthesis of findings

The findings of the research, derived from the three studies, are synthesised in this section according to the three main themes of the research. These include, as outlined in Chapter 1, developing a theoretical foundation for mobile learning, examining higher education students' utilisation of portable technologies to accomplish their routine study practices in formal and informal settings, and studying the relationship between context and students' learning activities.

8.2.1 Mobile learning

A key outcome of this thesis is the conceptualisation of mobile learning that addresses the limitations of the current definitions of the term. Mobile learning was defined in this thesis as: learning that occurs as a result of pursuing learning activities that are directed towards a given aim in multiple contexts (Wali et al., 2008a). The definition was based on the idea of context-crossing, where context was represented as both the physical and social setting of learning activities. Using context-crossing as a basis for the definition of mobile learning gave a new perspective on the term by shifting the focus from the technology used, as in some of the definitions in the literature (e.g. Kukulska-Hulme et al., 2005), to the context of use. In addition, the novel use of activity theory to study mobile learning illustrated context by using the tool component to represent the physical context (including any available devices) and using the rules, community and division of labour components to represent the social context. Changes in the physical context helped with differentiating mobile and static learning. Changes in the social context helped with studying what is interesting about mobile learning. This also helped with studying the innovative uses of portable technologies for learning by showing the changes that occur in the social context as a result of using portable technologies which would not occur if students used conventional devices to aid their learning. Thus, an important contribution of this thesis is the way the physical and social contexts of learning activities are represented through activity theory for the conceptualisation of mobile learning. This contrasts with Sharples et al.'s (2007c) representation of context in their activity system of mobile learning where both the physical and social contexts were represented through the 'community' component alone. In addition, the interplay between the physical and social conception of context differentiates the approach used to conceptualise mobile learning in this thesis from Sharples et al.'s (2007c) approach. This is further discussed in Section 8.3.1

8.2.2 Students' utilisation of portable technologies in formal and informal settings

This thesis explored students' utilisation of portable technologies in both formal and informal settings. The focus was on understanding how students use portable devices to accomplish their routine educational practices, rather than studying how the utilisation of these devices

impacts students' learning. The studies showed that students use a variety of old (e.g. handouts) and new (e.g. laptops) portable devices to facilitate their learning in formal and informal settings. The choice of device and its utilisation was affected by the context (physical and social) of learning activities. This is further discussed in Section 8.2.3.

The studies showed that students' utilisation of portables technologies in informal settings is similar to their utilisation in formal settings. Students used portable technologies such as laptops to accomplish curriculum-related tasks like viewing lecture slides, taking notes, searching for information on the web, using online dictionaries, and communicating with colleagues. In addition, portable technologies were used to subvert formal education in formal settings by engaging in activities that are not related to the topics discussed. The properties of portable technologies allowed students to engage in such activities without being noticed by instructors. For example, portables were used to engage in social activities such as online conversations and reading/writing emails. Portables were also used to engage in social activities in informal settings. Likewise, portable technologies were used to accomplish activities of personal interest such as playing games, browsing the web, and viewing pictures and videos in formal and informal settings. Moreover, portables were used to accomplish administrative tasks such as creating personal and curriculum-related documents and time management through calendars and timetables.

Students not only used portable technologies to aid their learning in formal and informal settings, they also used conventional devices as the main medium for undertaking learning practices. Students used conventional devices in formal and informal settings to accomplish curriculum-related tasks such as viewing lecture slides, taking notes, and solving exercises. In addition, conventional devices were used to subvert formal education and facilitate social activities as some students used them to write notes to each other. Conventional devices were also used to share representations and facilitate discussion.

The difference between using portable technologies when supplied as part of a study and when they are used as part of students' routine study practices

It was argued in Chapter 2 that the time spent using a technology can influence students' established use of technology to accomplish their routine study practices. This prompted the focus on the difference between students' portables utilisation when supplied as part of a study and when used as part of students' routine study practices. The studies showed that the time spent using a technology do not necessarily determine the extent of its integration in students' routine practices. For example, although some students in the studies have been using portable devices to support their learning in higher education context for a couple of

years (2nd and 3rd year students) (most students attended year 1 in the same institution), they have not become completely dependent on the devices to accomplish their routine study practices. Students also used conventional devices to facilitate their learning. In addition, the number of students using conventional devices in the 2nd and 3rd year was greater than in the 1st year.

The studies showed that the time spent using a technology has an impact on the development of students' expertise with the devices and the development of their ability to recognise the capabilities and benefits of the devices to aid learning practices. For example, 2nd and 3rd year participants, who have been using portable technologies in this setting for a longer time used their devices to pursue their routine study practices and engage in a wider variety of activities than 1st year students who have been using the technology for a shorter time. In addition, the students clarified that when portables were first provided to them by the university, they did not notice their benefits and they were not greatly used to achieve learning objectives. However, as they continued using the devices, students recognised their benefits, capabilities, and also the possibility of accomplishing most of their activities using them.

As discussed in Chapter 2, studying the differences between students' portables utilisation when used as part of students' routine study practices and when used as part of a study can be explored by comparing the study's findings with the findings of the literature that investigates students' adaptation of new technologies for learning practices. This includes studies that investigated students' adaptation of portable technologies for specific objectives such as using the devices as learning organisers (Corlett et al., 2005), to accomplish in-class activities (Granberg and Witte, 2005) and to engage in activities in informal settings (Facer et al., 2004). Some of the findings of the studies conducted in this thesis were similar to the findings in the literature. The studies showed that students used portable technologies to accomplish the same tasks as the students in the literature such as reading course materials, communicating and discussing issues with others, and using time management tools such as calendars. However, the students in the literature may have used portable technologies to accomplish tasks because they were directed to, rather than out of personal preference. Students used the provided devices to accomplish the activities suggested by researchers and thus altered their routine practices to include the new devices. The studies conducted in this research showed that when portable devices are used as part of students' routine practices, students use their portables to accomplish the same activities as the students in the literature but with less external influence. This shows the extent of technology integrated in students' learning activities and can be used as a baseline against which to interpret more interventionist studies.

Importantly, the research found that even when portable technologies are used as part of students' routine learning practices; they did not replace all of the other tools used to support learning. Waycott (2002) also found that providing students with PDAs to be used for reading course materials did not replace the tools that students usually used to support reading, such as printed material and desktop computers; PDAs were used in conjunction with these devices. Her study aimed at investigating whether PDA can be used as an alternative to printed material. This demonstrates how personal preferences can influence use, presenting the value of these studies as a benchmark for other work in the area. In addition, the studies conducted in this thesis showed that students perceive the portability of the technologies and the accessibility to learning resources as the main benefits of using portable devices to accomplish learning activities. This was also found in the literature (e.g. Waycott, 2002).

The influence of portables technologies on HE students' practices

The studies showed that portable devices, both portable technologies and conventional devices, enabled students to engage in learning activities in different contexts. The devices were used to accomplish curriculum and personal tasks, share representations, facilitate discussions and solve problems in formal and informal settings. The studies also showed that although students used conventional devices to accomplish many of the same tasks, portable technologies' features enabled students to accomplish activities that the students using conventional devices could not perform. For example, the portability of the technologies and accessibility to learning resources in different contexts enabled students to access resources and engage in learning and communicative activities across different contexts. Portables also enabled students to manage and arrange learning resources for easy access when needed. In addition, portables enabled students to change the topic they were working on without changing their context. Moreover, using portable technologies enabled students to create contexts that the students using conventional devices cannot create. For instance, students used their laptops to read posts on the VLE during instructors' illustrations in formal sessions. In these cases, students' context, which comprises the students' community (students and instructor), rules (view lecture slides and write notes) and the division of labour (student/instructor), changed to a new community which includes the student, new rules (access and read posts) and division of labour (learner). The changes in context mainly alter the social context of the learning activity which includes the rules and the division of labour of the students' community. This leads to innovative uses of portable technologies for learning.

Students' utilisation of portable devices to accomplish learning practices not only has positive influences, the devices also limited or distracted learning practices. The limitations of using

portable technologies to aid learning were mainly associated with the devices' properties and the ability to use these in certain contexts. Students viewed portable technologies' short battery life and the size of the device as factors that hinder achieving learning objectives in certain contexts. For example, the studies showed that laptops are not suitable to be used in situations where students are continuously on the move as they are large and heavy. Students replaced these with smaller and lighter devices such as handbooks which can be used to accomplish the tasks needed such as taking notes, even though they have fewer capabilities than portable technologies. The studies also showed that portable technologies can be easily used to subvert learning and engage in activities that distract from learning in both formal and informal settings. This is due to the devices' properties which enable engaging in various activities without being noticed. Finally, the lack of privacy and the limited availability of wireless connections limited the utilisation of portable technologies in formal and informal settings.

8.2.3 The relationship between context and students' learning activities

The studies showed that learning activities are affected by context, i.e. physical and social setting of learning activities, which both enables and limits accomplishing activities. In terms of the social setting, learning activities are influenced by the rules and division of labour which govern the community engaged in the learning activity. For example, the rules that governed the formal settings in the studies conducted in this thesis discouraged engagement in certain activities such as online conversations or face-to-face discussions. In these settings, students used their portable devices (old and new) to engage secretly in communicative activities. In terms of the physical setting, learning activities are affected by the features of the physical location where learning activities take place. In this research, portable devices were considered part of the physical setting as these can be used to engage in different activities and their availability and features influenced learning activities. For example, in the cases where students used portable technologies to aid their learning, students' learning activities were affected by the properties of the devices such as the size and battery life, the availability of resources such as power sockets and wireless connectivity, and privacy issues. The studies also showed that despite the differences between the context of formal and informal settings, students' utilisation of portable technologies in these settings is similar (discussed in Section 8.2.2). Students used their portable technologies in formal and informal settings to pursue a variety of activities that aided both formal and informal learning. This was mainly due to the properties of portable technologies that provide students with access to learning resources in different contexts and the ability to engage in activities without being noticed.

The research also showed that the institutional policy that provides students with access to portable devices and online learning resources, as in the second and third studies, affects students' utilisation of the technology to accomplish their routine learning practices. The studies showed that the dominant device used by students were laptops. At the same time, the studies showed that not all students used their laptops to pursue their learning activities. Some students preferred to use conventional devices mainly due to personal preferences and lack of expertise. In addition, the studies showed that the availability of laptops to students encouraged them to use the technology to accomplish tasks for which the students without the technology would use conventional devices instead. For example, students in the second and third studies used their laptops, through instant-messaging software and PowerPoint's notes area, to write notes and comments to colleagues, where the students in the first study used their handouts for the same purpose.

In settings with less availability of portable technologies, as in the pilot study, the dominant devices used to facilitate students' learning were conventional devices such as books and handouts. In these settings, students' utilisation of portable technologies to accomplish learning activities was limited. This was due to the influence of the physical context such as the limited availability of resources that enable using portable technologies like the technology, power sockets, wireless connectivity, and learning resources that can be accessed through the devices. In addition, the social context of the setting did not require students to use portable technologies to accomplish their learning objectives. Students were expected by their instructors to use conventional devices such as handouts to aid learning in formal settings. At the same time, the rules, division of labour and the learning experiences within these settings were built around using conventional devices to achieve learning objectives. For example, although some students in the pilot study had their laptops with them during classes, they did not use these to engage in learning activities; instead students used conventional devices.

Context, physical and social, also plays a major role in the choice of device used to pursue learning activities which therefore influences learning activities. For example, in terms of the physical context, the availability of wireless networks and power sockets affected the choice and the utilisation of portable devices. Thus, in cases of limited availability of these, students replaced portable technologies with conventional ones which enabled achieving the learning objectives. In addition, students' choice of device used to accomplish learning activities is affected by the properties of the devices. For example, the accessibility of learning resources through portable technologies determines whether the device can be used in settings with limited or no wireless connection. Moreover, the limitations of the devices may hinder using

these in certain contexts. For example, short battery life limits using portable devices in settings with limited power sockets. Furthermore, personal preferences to the way students approach their learning and personal expertise and familiarity with the devices influences students' choice of device. For instance, slow typing was a factor that limited students' utilisation of portable technologies in both formal and informal settings.

Context not only influences learning activities, it is also influenced by learning activities especially when using portable technologies to facilitate learning. Using portable technologies to accomplish learning activities can change the rules and division of labour of the students' community, thus changing the social context of learning activities. For example, students in the studies used their laptops in formal settings to engage in online conversation with others. In these cases, the students' community (students in the classroom and the instructor) changed to include the student and the person(s) chatting online. In addition, the rules (view lecture slides and write notes) and the division of labour (student/instructor) that governed the students' community changed to the rules (write a message and read response) and division of labour (one writes comment /one reads comment) that governed the activity of chatting online.

The impact of instructors' portables use on students' utilisation of portables

Instructors are part of the context that influences students' learning practices. The research showed that students' utilisation of portable technologies is affected indirectly by their expectations of instructors' utilisation of the devices. Students perceived their instructors to be experts in using portable technologies and thus they tended to copy instructors' actions such as copying their presentation style. In addition, students did not consider instructors' utilisation of devices as a factor that put them off using portable devices to accomplish their tasks as they did not witness bad experiences of instructors' portables use. Moreover, instructors' utilisation of devices gave students ideas of things they can do and resources they can find which encouraged them to use their portable technologies to accomplish these tasks.

Instructors' expectations of students' utilisation of portable devices (old or new) also indirectly influences students' behaviour and their utilisation of devices. For example, instructors are part of the context in formal settings and they shape the context, especially the social context, by their expectation of students' utilisation of devices. During formal sessions, students are expected by their instructors to use certain devices to accomplish tasks such as viewing lecture slides, writing notes and solving exercises. Students are also discouraged from engaging in certain activities that are not related to the session such as using instant-messaging applications. In addition, the type of device that learning resources are provided

through reflects the device that instructors expect students to use. This further influences students' choice and utilisation of device, to accomplish learning activities.

Instructors also influence students' utilisation of portable devices directly by asking them to accomplish certain tasks that require particular devices. The research showed this influence when instructors provided students with handouts and exercise sheets to be used during formal sessions. In addition, instructors usually asked students to look for online resources and use certain software applications; students accomplish the assigned tasks using their portable technologies. Instructors also influence students' utilisation of portable devices when asking students not to use their devices to engage in certain activities such as using instant messaging software in formal settings.

The impact of context on students' communication

The studies showed that context, physical and social, both enables and limits students' discussions and communication. Context also affects the method that students use to facilitate discussions in formal and informal settings. The studies showed that students engage in discussions through portable technologies (e.g. laptops and mobile phones), conventional devices (e.g. handouts) and face-to-face. The device that students use does not change students' discussions, but students use the available devices to facilitate their discussions. This was shown in the studies as students used different devices to communicate with each other in different contexts.

In terms of the physical context, the properties of the physical location, including the services available, affects students' communication. For instance, the availability of portable technologies, the ability to use these, and the availability of wireless connections affected students' ability to engage in online discussions. This was shown in the first study that was conducted in a university that does not implement a campus wide laptop program; students used their handouts and mobile phones to write notes to each other and engage in discussions. However, in the second and third studies, which were conducted in a university that implements a campus wide laptop program, students used their laptops as the main medium for their discussions, either using instant-messaging applications or writing notes in the notes area of PowerPoint slides.

In terms of the social context, the rules and division of labour of the community engaged in the learning activity affects students' communication. For example, instructors' expectations and the rules that govern formal settings usually discourage students' communication with others. The research showed that students' communication and discussions in these sessions

was usually done secretly using both portable technologies and conventional devices to write notes to each other. The studies also showed that students' communicate more freely in informal settings mainly due to the social context which does not restrict such actions as the formal settings do. Thus changes in students' practices that occur as a result of subverting formal education are more visible in formal settings than in informal settings.

8.3 Thesis contributions

This thesis's main contributions are to the field of educational technology. It contributes to the literature studying students' utilisation of technologies to facilitate learning practices, especially as part of their routine study practices, and the relationship between context and learning practices. This thesis also contributes to, and draws on, literature exploring the term 'mobile learning', which is conceptualised here by considering the context of learning activities and not the technology used. This thesis also contributes to the field of human-computer interaction (HCI) by providing insight into the utilisation of portable devices to accomplish learning practices and the factors that influence and are influenced by learning activities which are useful for technology and resources developers. The following discussion examines the contributions in more detail.

8.3.1 Developing a conceptualisation of mobile learning

This thesis contributes to the field of educational technology with a conceptualisation of mobile learning that addresses the limitations of the current definitions of the term. It is of particular relevance to the growing number of researchers who are interested in studying and understanding mobile learning. It is also relevant to researchers who are interested in developing theories of mobile learning, particularly through activity theory (e.g. Sharples et al., 2007c). Moreover, this thesis contributes to the novel use of activity theory to study mobile learning. In this respect, Engeström's (1987) expansion of activity theory was used as an analytical framework to examine mobile learning in terms of the context in which tools are used, broadening the scope beyond the technology used, considering both the physical (through the tool component) and social (through the rules, community and division of labour components) settings of learning activities. The definition also provided insight into the innovative uses of portable devices to accomplish learning activities by highlighting the changes that occur in the social context of learning activities (Wali et al., 2008a).

The conceptualisation of mobile learning developed in this thesis contrasts with Sharples et al.'s (2007c) definition of mobile learning, discussed in Chapter 2, which also used activity theory. The analysis of mobile learning proposed in Sharples et al. (2007c) was complicated by introducing two layers, semiotic and technological, to Engeström's (1987) expansion of

activity theory. The conceptualisation of mobile learning introduced in this thesis used Engeström's model to represent activities (including the semiotic and technological elements of such systems) in relation to their context, eliminating the complexity introduced by the two layers proposed in Sharples et al.'s (2007c) framework. The definition also de-emphasised the researchers' focus on students' communicative interactions and focused on the continuity of students' learning activities that may be mediated by portable devices (old or new) and are directed towards the same objective in different contexts. Moreover, the representation of context through activity theory for the conceptualisation of mobile learning in this thesis differs from Sharples et al.'s (2007c) representation, where both the physical and social contexts were represented through the 'community' component of an activity system. In this thesis, the social context was represented through the rules, community and division of labour components and the physical context was represented through the tool component. Using the tool component to represent location is novel, as the component is usually used to represent just the devices that students use to facilitate their learning. In this thesis, location was perceived as the tool that makes learning mobile.

Therefore, the conceptualisation of mobile learning introduced in this thesis could be a useful analytical tool for future research that aims to understand mobile learning. It provides researchers with a tool to look at mobile learning in terms of the context of use and shifts the focus from the device used to facilitate learning, which is the focus for many of the techno-centric definitions of mobile learning in the literature. The definition helps focus on the form of people's practices involving any technology and how these practices vary across contexts. It also encourages researchers to look at the features (both physical and social) of the learning environment which aids studying the innovative uses of portable devices for learning.

8.3.2 An examination of real-world cases of the utilisation of portable technologies for learning

This thesis contributes to the current discussion of the utilisation of portable devices for learning by highlighting real-world cases of students' portables use to aid their learning activities in multiple settings (formal and informal) which is under-reported in the literature. Most of the studies in the literature focus on exploring the utilisation of new and small devices such as PDAs and mobile phones in specific settings (e.g. Papadimitriou et al., 2007; Sharples et al., 2007b). The exploration in this thesis focused on the utilisation of devices (old and new) that students already use as part of their day to day learning activities such as laptops and conventional devices such as handouts. The focus was on practices that are already there and devices that students already use without the intrusion of researchers. This also helped with developing the understanding of mobile learning by highlighting that it is not

about the use of new and small devices and the utilisation of these in new and innovative ways, but about how people appropriate the tools for their own use supporting their practices with the devices that are available to them across contexts.

8.3.3 An examination of the utilisation of portable technologies to accomplish routine learning activities

This thesis contributes to the literature exploring the impact of portable technologies on students' learning activities through exploring some of the issues that require more investigation in the literature. These issues are outlined here (Section 8.2 discussed these in detail).

First, this thesis has examined how portable devices (old and new) have been used in real-world cases to accomplish routine learning activities. The review of the literature has shown that there are limited studies that focus on studying students' established use of portable devices as part of their routine learning practices. The studies in the literature had mainly focused on studying the impact of introducing particular new technologies on students' learning activities. In these studies, students usually adjusted their learning practices to embed the new technology and used the devices to accomplish the tasks suggested by researchers. In addition, the studies conducted in this thesis did not focus on particular portable devices, as in the literature, but they studied the utilisation of both old and new portable devices used by students to accomplish their routine study practices and how these devices were used interchangeably to accomplish learning objectives.

Second, studying students' utilisation of portable devices to accomplish routine study practices helped with investigating the influence, both benefits and limitations, of using these devices for learning activities. This widens the literature's discussion of this issue. The study showed that the benefits and limitations of using portable devices for learning are mainly related to the properties of the devices used.

Third, students' learning activities have been studied in relation to their context considering both the physical and social features of learning activities. Drawing on one of the main aims of this thesis, investigating students' utilisation of portable devices to accomplish routine learning practices, required studying these activities in relation to the context (physical and social) of these activities. In contrast, the studies in the literature focused on studying students' learning mainly in relation to specific subject areas or settings and using the devices for specific purposes. These studies were limited in their focus on the impact of the change in context on learning activities. Studying the relationship between context and learning

practices has helped with understanding students' utilisation of portable devices to accomplish routine study practices in formal and informal settings. In addition, this thesis studied the impact of instructors' technology utilisation on students' technology utilisation which has been relatively limited in the literature. The studies showed that instructors influence students' utilisation of portable devices both directly and indirectly. Moreover, the relationship between context and students' communication has been investigated. The studies showed that the changes in students' communicative interaction in formal settings are more visible than in informal settings. This is mainly due to the rules of formal sessions, which discourage communication with others and therefore the subversion of formal education. Engaging in discussions with others is more obvious in formal settings than that in informal settings where students usually engage in such activities.

Engeström's (1987) expansion of activity theory was used as an analytical framework to conduct the studies in this thesis and investigate the above issues. The theory's first guideline, that activities should be understood in relation to context, helped with studying students' learning activities in relation to their setting (physical and social). In addition, the second guideline of activity theory, that activities are in constant development and transformation, was used to track the continuity of learning activities in different contexts. Activity theory's third guideline, that developments in activity systems are driven by the contradictions within and between these activities, was used to study the development of activities as a result of contradictions that occur in the activity system.

8.3.4 Methodological contributions

The research conducted in this thesis used a different approach to investigate the issues of concern than the approaches usually used in the literature. The studies in the literature explored mobile learning mainly through students' self-reports collected through questionnaires and interviews. The studies did not triangulate these responses with data that represent students' actual use of the technology for learning. The studies also lacked detailed description of students' learning practices that take place in and across multiple contexts. Thus, the methodology used in this thesis focused on using research methods that can provide detailed description of learners' practices and enable studying the longitudinal pattern of these in and across contexts (formal and informal). In addition, the methodology focused on using methods that enable capturing information about the context (physical and social) which influences and is influenced by learning activities. The methodology also focused on triangulating students' self-reports with data collected through other research methods and which represents students' actual use of the technology for learning. This helped with providing evidence on how accurate students' responses were and thus improving the

accuracy and validity of the collected data. In this thesis, students' self-reports were collected through questionnaires and interviews. These were then triangulated with data collected through observations of students and log files collected through system monitoring software installed on students' laptops. The methodology used in this thesis could be useful for studies in the area of the research as it provides (a) the ability to study learners' activities that aim at achieving an objective and take place in and across different contexts, (b) providing information about the context of learning activities and (c) ensuring the accuracy and validity of learners' self reports (Wali, 2007; Wali et al., 2008b; Wali et al., forthcoming).

As this thesis aimed at studying students' utilisation of portables for routine learning activities, the sample involved students who are considered to be immersed in using technology for their routine learning practices. Although the year of study alone does not determine how immersed students are in using a technology, the studies focused on 2nd and 3rd year higher education students. In addition, the same group of students were studied in multiple formal settings such as different courses, unlike the studies in the literature which focused on studying students enrolled in the same course. Students were also studied in informal settings such as the library. This helped with showing the similarities and differences in students' utilisation of portable devices in different contexts.

This thesis also provided information about the time needed to study students' learning activities for similar studies. The research showed that few novel patterns of behaviour were witnessed after the third week of observations of students.

8.4 Limitations of study

This section discusses the limitations of the methods and theory employed by the research.

8.4.1 Practical Limitations

There were a variety of practical and ethical limitations on the collection of data in the university environment concerning students' confidentiality and privacy. In the second study, although the university was assured that the data would be handled in a professional and confidential manner, agreement to observe students in informal settings and install system monitoring software on students' laptops was not granted. These restrictions hindered studying students' utilisation of portables in informal settings and triangulating students' questionnaire responses. However, this limitation was overcome in the third study where permission was granted.

Another limitation of this study concerned the limited number and variety of participants. Although students were assured the confidentiality and anonymity of the collected data,

students' participation in the study was limited mainly due to privacy concerns in relation to installing system monitoring software on their laptops. Having a larger number and wider variety of participants could have helped with providing different views on students' utilisation of portable devices.

In addition, the study aimed at video recording students in both formal and informal settings to enable analysing students' utilisation of portable devices. However, this could not be implemented as the participants refused to be recorded on video and requested to be observed. Having the video records could have helped with providing detailed description of the observational data and would have acted as a baseline for referring back to unclear points that had arisen in the observational notes. In addition, video recording would have helped with analysing the cases using activity theory.

The research focused on studying students' utilisation of portable technologies mainly in one university that implements a campus wide laptop program and another university that does not have such a program. The generalisability of the research findings is therefore limited. Having more time and access to other universities that implement similar programs would have provided the opportunity to present a broader discussion of students' practices using portable technologies, considering a wider range of participants and different settings.

8.4.2 Analytical Limitations

Using activity theory as an analytical framework both enriched and restricted the research. As discussed in Chapter 2, activity theory is not actually a 'theory' in the strict interpretation of the term. Rather it consists of a set of principles that are open to interpretation and can be used as a foundation for more specific theories. Activity theory was used in this research to investigate the issues of concern to this thesis and mainly to understand and develop a conceptualisation of mobile learning. Mobile learning in this thesis was interpreted in relation to the concept of context-crossing where context was conceptualised as the physical and social setting of learning activities. The physical context was represented in an activity system as the tool that makes learning mobile, and the social context was represented as the rules and division of labour of the community engaged in the activity. However, some researchers might consider this conceptualisation incorrect. In the literature, the tool component is usually described as the artefact that humans use to facilitate their activities such as physical tools (e.g. devices) and conceptual tools (e.g. language). In the mobile learning model presented in this thesis, the tool component has been considered as the location where learning activities take place because this is a designed and purposeful artefact with its own history. In addition, a change in the physical location was considered as the tool that makes learning mobile.

The conceptualisation of mobile learning introduced in this thesis can be used to study what is socially interesting about mobile learning through studying the changes in the social context represented as the rules and division of labour of the community engaged in the activity. However, as a consequence of activity theory's historical perspective, it must be recognised that what makes mobile learning socially interesting may dwindle over time, in which case learning that was interesting may become ordinary. Learning will still either be mobile or not; the historical aspect only affects one of the two dimensions when analysing a case.

Moreover, studying mobile and static learning in the studies conducted in this thesis showed that the cases of static learning usually represent brief incidents of activities pursued by students which, if continued over time in different contexts, will cause students' learning to be mobile. The studies showed that the time frame in which data is collected affects the classification of learning. The longer the time that students' learning activities are studied, the greater the chance to observe more instances of activities carried out previously which will make the classification of learning mobile instead of static.

8.5 Further research

This thesis raised issues that would benefit from future research. As noted above, one of the limitations of the research is that it was conducted in one university that implements a program that supplies students with laptops to be used to aid learning practices. This limited the number and variety of participants and thus the generalisability of the research findings. To extend the findings of the research, other universities that implement similar programs should be involved in a future study to include a wider range of participants and descriptions of learning practices.

In addition, in a doctoral study, time is limited. Having more time to study students' learning practices that are mediated by the use of portable technologies over a few years, as a longitudinal study, would provide an insight into the wider variety of students' practices using portable devices. In addition, it would provide information about the development in students' practices to accomplish routine learning activities using portable devices over time.

This research investigated how students use portable devices to accomplish their routine study practices but did not contrast this with their use of unfamiliar devices, which would have provided an insight into how such technologies become embedded in practice. The study can be extended by examining empirically the impact of using portable technologies on students' learning when devices are used as part of students' routine study practices and comparing that with students' learning when these are first provided to students. The study can also be

extended by studying the impact of portable technologies on students' communication as the review of literature showed contradictions regarding this issue. Some studies claimed that using portable technologies increases communication between students and others claimed that technologies did not affect that. Moreover, future studies can focus more on studying learning that continues to occur in the same location over time such as classrooms. This can clarify the relationship between learning activities and the social context within the same physical context. Future research can also look at the limitations of the conceptualisation of mobile learning introduced in this thesis and test the framework in other research settings.

8.6 Implications for educational policy and practice

The findings of this thesis have a number of implications for educational policy makers who are interested in making decisions as to whether or not to supply students with portable technologies. The studies showed that the benefits of using portable devices for learning outweigh the limitations. Thus, providing students with portable devices to facilitate their learning is beneficial because portables enable students to accomplish tasks and create contexts that the students using conventional devices can not do or create. For example, portables enable students to engage in learning activities and provide them with accessibility to people and learning resources across contexts. Policy makers should also consider utilising the educational benefits and minimising the limitations of using portable devices to facilitate learning. This also affects the extent of the integration of the devices in students' routine study practices. For example, the studies showed that portability, convenience and accessibility to information are the main benefits of using portable devices for learning; policy makers should exploit these benefits by enabling students' utilisation of devices in different contexts. In addition, the studies showed that the limited availability of the resources, such as power sockets and wireless connectivity, needed to use portable devices in different contexts is a major limitation of using portables for learning. Policy makers should consider these limitations and grant students access to the needed resources in different contexts.

The studies also benefit policy makers by providing insight into the importance of studying the environment in which learning activities take place before taking decisions in relation to the technology to be provided to students. The studies clarified that the context (physical and social) of learning activities influences students' choice of the devices (old or new) and their ability to use the devices in certain contexts. The studies also showed that supplying students with portables requires carefully studying the capabilities and limitations of the devices which may enrich and restrict learning activities. This also affects the integration of the technology in students' routine learning activities. For example, it was shown in the studies that even

though students were supplied with laptops to be used to aid their learning in formal and informal settings, students used these in conjunction with other conventional devices such as handouts. This was mainly due to students' inability to use laptops in some contexts as they were continuously on the move. In addition, the properties of the devices, such as large size and heavy weight, hindered using them in such contexts. Moreover, the studies showed that in order for students to utilise portable technologies for their learning, and the technology to be integrated in their routine learning practices, they require some training, especially for novice users, to overcome the difficulties of using the devices for learning and provide students with information of how to utilise the devices' features for their learning. Therefore, policy makers should consider providing students with the essential technology education when supplying students with portable devices. Furthermore, the studies showed that providing portable technologies should be aligned with providing the resources that enable using the devices in different contexts such as learning resources compatible with the devices, power sockets and wireless connections. This also improves the integration of the technology in students' routine learning practices.

In addition, the research findings benefit course designers and teachers who are interested in designing courses for students on the move. This thesis provides course designers and teachers with examples of activities that students pursue in different contexts, the type of portable devices (old or new) used in these contexts and the impact of context on the choice and the utilisation of devices. The studies showed that students use both old and new portable devices to accomplish learning activities in formal and informal settings. In addition, it was shown that students engage in a variety of activities that aid and distract learning in formal and informal settings. Therefore, teachers and course designers should, in the first place, understand what technologies students use in different contexts before designing learning resources. Second, they should understand the application of these devices in multiple contexts. The studies also showed that context influences and is influenced by learning activities, thus, teachers and course designers should understand the context, both physical and social, of the learning activities and design learning resources accordingly. This helps with considering the availability of certain services (e.g. power sockets, wireless connectivity) that aids students' learning activities in these settings. Teachers and resource designers can also benefit from this thesis's discussion of the benefits and limitations of using portable technologies when designing learning resources to be used in different contexts. Thus utilising the benefits and controlling the limitations. Moreover, this thesis's findings provide course designers with ideas for enhancing and creating innovative learning experiences for both formal and informal settings. For example, learning resources provided to students in lab and tutorial sessions, in the studies, were based on using conventional devices such as

handouts. Learning resources could benefit from the properties of portable devices, such as mobility and accessibility to colleagues and learning resources, and the properties of the physical and social context of learning activities to design innovative learning experiences that include processes for discussion between students and accessing different sources of information. This consequently improves the integration of portable devices in students' routine learning practices as students use the devices to accomplish most of their practices.

The findings of the research have also implications for technology designers. The studies showed that developing technologies that are used by students should be compatible with students' needs and the learning activities they pursue in different contexts (formal and informal), and the context (physical and social) of learning activities. Designers can benefit from the discussion of the benefits and limitations of portable devices for learning in order to employ the benefits and consider the limitations for the design of new technologies that are compatible with and capable of dealing with students' needs in different contexts.

This thesis also provided an insight into the implementation of campus wide laptop programs. The studies showed that the implementation of these programs could be useful but, without significant changes to the traditional curriculum and delivery methods, the integration of technologies in students' routine activities would be difficult. The studies showed that the use of portable technologies could have been more profound if the curriculum and teaching methods were built around using the technology. The studies also showed that it is not enough to supply all students and staff with portable devices to be used to accomplish their tasks; the technology should be integrated in most educational activities. For example, the studies showed that although students' learning was expected to be through their laptops, students were examined through paper and pen and were supplied with printed handouts (e.g. lab handouts) to be used in some formal sessions. The study also showed that the implementation of portable devices in teaching is partially dependent on the teacher. Teachers' utilisation of devices for the curriculum and their expectations of students' utilisation of these influences students' practices. In other words, the social context should be designed to encourage the use of portable devices, not just the physical context. Moreover, the research showed that the implementation of campus wide laptop programs could benefit from the opportunities offered by portable technologies to create innovative learning experiences that can not be done through the use of other conventional devices.

8.7 Conclusion

This thesis has examined higher education students' utilisation of portable devices to accomplish routine learning practices in formal and informal settings. This thesis contributes,

first, to the growing literature concerned with understanding and developing theories of mobile learning. It provides a conceptualisation of mobile learning that addresses the limitations of the current definitions of the term. In addition, it presents a novel use of activity theory as an analytical framework for exploring mobile learning based on the idea of context crossing where context comprises both the physical and social setting of the learning activity. Second, this thesis examines students' utilisation of portable technologies to accomplish their routine learning practices in formal and informal settings and considers the relationship between these and the context of learning activities. Third, this thesis offers methodological considerations for related studies by (a) triangulating self report data with data gathered through other techniques which provide evidence about students' self reports, (b) collecting detailed data about students' learning practices that take place in multiple contexts (formal and informal) and (c) collecting in-depth data about the context of learning activities. These contributions could be useful for guiding future research that studies the utilisation of portable devices and further developing the discussion of mobile learning. In addition, they may be useful for people interested in resource design for students on the move, in the design and implementation of new technologies in learning spaces, for policy makers who decide whether to provide students with portable technologies, and for teachers who use the technology as a tool.

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Appendix A

Student's Consent and Authorisation form[1]

The following information is provided for you to decide whether you wish to participate in the present study. You may refuse to sign this form and not participate in this study. You should be aware that even if you agree to participate, you are free to withdraw at any time. If you do withdraw from this study or wish not to complete any part of the study, it will not affect you in any way. You can be assured that all the information supplied will be treated in a professional and confidential manner. Your name is not essential but would be helpful for possible follow-up on a later date.

I am a PhD candidate in the Institute of Education at University of London. The title of my PhD research is *Investigating the Impact of Integrating Portable Technologies on Higher Education Institutions.*

Portable computers are personal computers that are designed to be easily transported and relocated. During the last few years portable devices, such as PDAs, mobile phones, laptops and tablet PCs, have become integrated in day-to-day activities including education. My research is concerned with studying higher education students' utilisation of portables for formal and informal learning activities. My research also aims to analyse the benefits and limitations of utilising portables' for learning, their impact on students' communication inside and outside the classroom, and the impact of instructors' utilisation of technology on students' utilisation of technology. The research has gone through the standard procedures of ethical approval and it has already been piloted twice.

Your participation may include: *(Please specify which of the following you would **not** like to participate in)*

1. Answering a questionnaire
2. Being observed while working on your portable technology
3. Being recorded on video during class
4. Installing system monitoring software on your laptop which will help clarifying what applications you use your laptop for and when they were used. This will aid in studying your portable usage for formal and informal learning activities inside and outside the classroom and investigating how instructors' portables utilisation affects your portable utilisation. You can be assured that I will **NOT** be looking at the web sites you visit or the applications you use, and you will **NOT** be identified by the logs[2] in any way.
5. Interview

[1] The form is adapted from www.research.ku.edu/kucr/forms/comp/hscl/s-pg-con.doc

[2] Log files are files that list a sequence of events that have occurred when a student uses a computer

Participant Certification

I have read this Consent and Authorization form. I have had the opportunity to ask, and I have received answers to, any questions I had regarding the study. I understand that if I have any additional questions about my rights as a research participant, I may contact the researcher, email: EWali@IoE.ac.uk.

I agree to take part in this study as a research participant. By my signature I affirm that I have received a copy of this Consent and Authorization form.

Name _____

Email _____

Signature _____

Date _____

Researcher Contact Information:

Esra Ahmed Wali

EWali@IoE.ac.uk

Appendix B

Instructors Letter

Dear Dr... ,

I am currently a PhD candidate in the Institute of Education at University of London. The title of my PhD research is Investigating the Impact of Portable Technologies on Higher Education Institutions.

I am about to embark a study to find out how students at the University are using portable technologies in their learning. I need your help to provide me access to any of your undergraduate classes to be able to survey students and observe them while they are using their portables inside the classroom. I would also like to video record your classes based on your and students' approval.

You can be assured that all the information will be treated in a professional and confidential manner. Students' identities will be kept anonymous.

My study depends on people like yourself providing me access to classes. I thank you very much in anticipation of your support.

Yours sincerely,
Esra Wali
Department of Mathematics, Science and Technology
Institute of Education
University of London
Email: EWali@IoE.ac.uk

Appendix C

Student's Questionnaire [3]

Student's Information:

Q1 - Gender

1. Male ..... ☐
2. Female ..... ☐

Q2 - What portables do you use?

1. Laptop ..... ☐
2. PDA ..... ☐
3. Mobile phone ..... ☐
4. Other (Specify) .....

Q3 - How long have you been using your portables? ***(Please tick the appropriate box)***

	Less than a year	One year	More (Specify)
Laptop			
PDA			
Mobile phone			
Other			

Using portables for formal learning activities

Q4 - How often do you use your portables in the classroom?

1. Less than once a week ..... ☐
2. Once a week ..... ☐
3. A few days a week ..... ☐
4. Every day ..... ☐
5. Do not use ..... ☐

Q5 - What are the applications that you use in the classroom?

1. Word Editor ..... ☐
2. Presentation ..... ☐
3. Spreadsheet ..... ☐
4. Web browser ..... ☐
5. Email ..... ☐
6. Calculator ..... ☐
7. Other (Please specify) .....

[3] Some of the questions were adapted form a similar study (Waycott, 2004)

Q6 - What are the purposes of using your portables inside the classroom? ***(Please tick all the appropriate boxes)***

	Laptop	PDA	Mobile phone	Other
Taking notes				
Viewing instructor lecture notes				
Access Internet sites				
Chatting with colleges				
Asking questions				
Reading course materials				
Playing games				
Reading email				
Writing emails				
Reading e-books				
Using spreadsheets				
Editing word documents				
Others (Specify)				

Q7 - Would you like to use your portables more inside the classroom?

1. Yes ..... □
2. No ..... □

If 'Yes'

Q7.1 - What stops you from using your portables more inside the classroom?

_____

_____

_____

_____

Q8 - What encourages you to use your portables inside the classroom?

_____

_____

_____

_____

Using portables for informal learning activities

Q9 - How often do you use your portables outside the classroom?

1. Less than once a week ..... □
2. Once a week ..... □
3. A few days a week ..... □
4. Every day ..... □
5. Do not use ..... □

Q10- What are the applications that you use outside the classroom?

1. Word Editor ..... ☐
2. Presentation ..... ☐
3. Spreadsheet ..... ☐
4. Web browser ..... ☐
5. Email ..... ☐
6. Calculator ..... ☐
7. Other (Specify) .....

Q11 - What are the purposes of using your portables outside the classroom? ***(Please tick the appropriate box)***

	Laptop	PDA	Mobile phone	Other
Taking notes				
Viewing instructor lecture notes				
Access Internet sites				
Chatting with colleges				
Asking questions				
Reading course materials				
Playing games				
Reading email				
Writing emails				
Reading e-books				
Using spreadsheets				
Editing word documents				
Others (Specify)				

Q12 - Would you like to use your portables more outside the classroom?

1. Yes ..... ☐
2. No ..... ☐

If 'Yes'

Q12.1 - What stops you from using your portables more outside the classroom?

_____

_____

_____

_____

Q13 - What encourages you to use your portables outside the classroom?

_____

_____

_____

_____

Portables' benefits and limitations

Q14 - How useful do you believe portables are: ***(Please tick the appropriate box)***

	Not useful	Somewhat useful	Very useful
Inside the classroom			
Outside the classroom			

Q15 - Why do you believe portables will/will not be useful for in-class learning activities?

Q16 - Why do you believe the portables will/will not be useful for out of class learning activities?

Portables and students' communication

Q17 - How often do you use your portables for communicating with others (students and/or others)? ***(Please tick the appropriate box)***

	Inside the classroom	Outside the classroom
Daily		
Weekly		
Monthly		
Never		

Q18 - How often do you communicate with other students face-to-face? ***(Please tick the appropriate box)***

	Inside the classroom	Outside the classroom
Daily		
Weekly		
Monthly		
Never		

Q19 - How often do you communicate with other students using online techniques such as instant messaging (e.g. MSN Messenger), bulletin boards or emails? *(Please tick the appropriate box)*

	Inside the classroom	Outside the classroom
Daily		
Weekly		
Monthly		
Never		

Q20 - What is the purpose of your communication with other students? *(Please tick all the appropriate boxes)*

	Inside the classroom	Outside the classroom
Discussing topics illustrated in the classroom		
Asking questions about the discussed topic in the class		
Discussing things not related to the discussed topic		
Chatting with friends and family		
Other		

Q21 - How has the use of portable devices helped you to communicate with others?

Q22 - How has the use of portable devices hindered you from communicating with others?

<u>The impact of instructors' technology use on students' utilisation</u>

Q23 - Has the instructor's use of technology ever given you ideas for things to do or try? (Please explain)

Q24 - How do the tasks set by your instructors' encourage or require you to use portable technologies?

Q25 - Has the instructor ever done anything that prevented or dismounted you from using portable technologies? (Please explain)

General perceptions of portables

Q26 - How do you travel to the university?

Q27 - How long is your journey to the university?
_____ minutes

Q28 - Do you use your portables while travelling? ***(Please tick all the appropriate boxes)***

Laptop	
PDA	
Mobile phone	
Other	

Q29 - What for?
Laptop

PDA

Mobile phone:

Other

Q30 - How often do you bring each of the following to class with you: ***(Please tick all the appropriate boxes)***

	Daily	Weekly	Monthly	Never
Laptop				
PDA				
Mobile phone				
Other				

Q31 - Overall, how useful are your portables? ***(Please tick the appropriate box)***

	Laptop	PDA	Mobile phone	Other
Not useful				
Somewhat useful				
Very useful				

Q32 - We would like to understand the extent to which your use of portables is part of your day-to-day study. In order to help us understand this, we would like you to think about this hypothetical situation:
If your portables were taken away and you were not allowed to replace them, what effect would this have on you and your work:

Laptop:

PDA:

Mobile phone:

Other:

Q33 - What other comments do you have about your experience of using portables?

Thank you very much for your time and cooperation

Appendix D

Observations Sheet

Class:	**Date:**
Time:	**Notes:**

Application	Start time	End Time	Purpose	Relation to Instructor's portable usage	Notes

Appendix E

Boss Everyware and Activity Logger descriptions

Boss Everyware 2.81 Features (adapted from http://www.bosseveryware.com/):

1. Boss Everyware keeps a log of which programs that a user has run, and how much time they've spent on them
2. It records all of the users' keystrokes
3. It logs inactivity if the user hasn't made any clicks or keystrokes for some time
4. It makes it easy to answer questions about what new software has been installed, what software has been used and what specific web sites are being visited.
5. The program can be password protected, and accessible only to the network administrator.
6. Boss Everyware's data logs can be written in delimiter-separated values, dBase or in a proprietary encrypted format, and exported to popular database and spreadsheet programs.
7. The program's powerful internal reporting system lets you select data by user or by application, create filters for including or excluding information, and arrange the data in a variety of useful ways.
8. You can control how to group the data, whether to show full URLs or just domains, whether to display the non-character keystrokes, and other functions that determine the usefulness and appearance of the reports.
9. Data logs written in delimiter-separated values format can be placed on write-only locations, preventing users from reading and deleting captured data.
10. The application runs under Windows NT4/2000/XP/95/98/Me, including Microsoft Terminal Services and Windows XP Remote Desktop Connection.

Activity Logger 2.5 Features (adapter from http://www.softactivity.com/spy-software.asp):

1. Monitor Internet usage: records to the log file URLs of visited Internet sites with viewed page title
2. Records keystrokes in email, chat, instant messengers and other programs
3. Logs what programs users run and how long do they work in every program
4. Recorded log file can be periodically sent silently to your email address, when computer goes online
5. Capture and save screenshots of computer desktop every several seconds. Snapshots do not take a lot of disk space, because they are saved in the compressed JPEG format. Captured screenshots can be viewed as a slide show with the provided viewer utility or any third party image viewer.
6. All configuration and reporting features are protected with a password. Only you have access to the gathered log data.
7. Advanced reporting features allow viewing recorded log data in different presentations to analyze user's activities on your computer.
8. Log file can be conveniently viewed as an HTML in web browser with embedded screenshots.
9. Log files can also be viewed in MS Excel format, which allows to view users activity, filter and group data, to see work summary table, create graphic diagrams and view Internet usage history

Appendix F

Analysis Sheet

- **Portable device – mobile learning**

  Description:

  Interpretation (using AT and/or MLP):

- **Portable device – static learning**

  Description:

  Interpretation (using AT and/or MLP):

- **Conventional device – mobile learning**

  Description:

  Interpretation (using AT and/or MLP):

- **Conventional device – static learning**

  Description:

  Interpretation (using AT and/or MLP):

Appendix G

Log Files Analysis Sheet

Date	Time	Application	Purpose	Notes

Appendix H

List of publications

1. Wali, E. (2007), *Are they doing what they think they're doing? Tracking and triangulating students' learning activities and self reports.* Paper presented at the WLE Workshop on "Research Methods in Informal and Mobile Learning: How to get the data we really want", WLE Centre of Excellence, Institute of Education, London, UK.

2. Wali, E., Winters, N. and Oliver, M. (2008a), 'Maintaining, Changing and Crossing Contexts: an Activity Theoretic Reinterpretation of Mobile Learning'. *Association for Learning Technology Journal*, 16 (1), 41-58.

3. Wali, E., Winters, N. and Oliver, M. (2008b), Mobile Learning Across Contexts: Methodological Considerations, *IADIS Mobile Learning*, Algarve, Portugal.

4. Wali, E., Winters, N. and Oliver, M. (forthcoming), 'Are they doing what they think they're doing? Tracking and triangulating students' learning activities and self reports'. In G. Vavoula, N. Pachler and A. Kukulska-Hulme (eds.), Researching Mobile Learning: Frameworks, Methods and Research Designs. Oxford, Peter Lang Publishing Group.

Appendix I

A sample of log files analysis sheet

Date	Time	Application	Purpose	Notes
18-11-05 Friday	9:16	JCS IE	open the page	In the lab (15)
	9:49	Outlook	Reading emails	(CRP) (10-11)
	09:52	JCS	Start simulator & write code based on the simulator (adaptive and productive)	
	9:54		connect to the wireless network	
	9:57	JCS + Editor + Excel	Simulator + writing codes + copying results in an excel sheet	
	10:07	MS Visio	work on the diagrams about mobile learning	
	10:12	Outlook	Reading emails narrative	
	10:14	Excel	Back to previous choice tasks on simulator + reading from website (comparing) repeated	
	10:28 DSO	Adobe Reader	Reading through an assignment related to the simulator	
	11:04	WORD	go through lecture notes & write comments	During the breaks
	11:38	Notepad	Add an exercise in the "TODO" file	
	11:41	IE	Browsing Interactive	

Date	Time	Application	Purpose	Notes
21-11-05 Friday	11:46	IE	Read through the assignment sheet (Diagram)	(16)
	11:52	IE	Browsing	Break
	12:04	Word	Go through lecture notes (RP)	Second lecture
	12:09	IE	Go to course website & download some review on solutions (CRP)	
	12:20 - 12:55	Word	Opening lecture notes going through them & using the simulator at the same time	
	13:38 - 13:55	Adobe Reader	Views the downloaded revision solutions	during a lab
***	13:58 - 14:08	~	Reading a published paper narrative	session
	14:36	Outlook	Reading emails	Screenshot not classroom
	14:38	Sync	Sync	we no lecture
21-11-05 Monday	01:30	Sync	Sync	
	01:52	Notepad	Open TODO file and	at home
	2:41		Syn & continue	

Appendix J

A sample of a completed questionnaire

C'S

11

Questionnaire

Student's Information:

Q1 - Gender

1. Male ☑
2. Female ☐

Q2 - What portables do you use?

1. Laptop ☑
2. PDA ☑
3. Mobile phone ☑
4. Other (Specify) .....

Q3 - How long have you been using your portables? ***(Please tick the appropriate box)***

	Less than a year	One year	More (Specify)
Laptop	✓		
PDA			4 yr.
Mobile phone		✓	
Other			

Using portables for formal learning activities

Q4 - How often do you use your portables in the classroom?

1. Less than once a week ☐
2. Once a week ☐
3. A few days a week ☑
4. Every day ☐
5. Do not use ☐

Q5 - What are the applications that you use in the classroom?

1. Word Editor ☑
2. Presentation ☐
3. Spreadsheet ☐
4. Internet Explorer ☐
5. Email ☐
6. Calculator ☑
7. Other (Please specify) ✓

PIM (Personal information management)

1

Q6 - What are the purposes of using your portables inside the classroom? ***(Please tick all the appropriate boxes)***

	Laptop	PDA	Mobile phone	Other
Taking notes		✓		
Viewing instructor lecture notes	✓			
Access Internet sites				
Chatting with colleges	✓			
Asking questions				
Reading course materials	✓			
Playing games				
Reading email	✓			
Writing emails	✓			
Reading e-books				
Using spreadsheets				
Editing word documents				
Others (Specify) Completing set task (i.e. lab exercises.)	✓			

Q7 - Would you like to use your portables more inside the classroom?

1. Yes ..... ☑
2. No ..... ☐

If 'Yes'

Q7.1 - What stops you from using your portables more inside the classroom?

- Lack of space in lecture theatres
- Lack of power supply in lecture theatres / lab.
- Unpatient of low interaction
- Battery life (lack of)

Q8 - What encourages you to use your portables inside the classroom?

- Convinient of having all your notes in 1 place.
- Having a system personalized to your own needs / preference.

Using portables for informal learning activities

Q9 - How often do you use your portables outside the classroom?

1. Less than once a week ..... ☐
2. Once a week ..... ☐
3. A few days a week ..... ☐
4. Every day ..... ☑
5. Do not use ..... ☐

Q10- What are the applications that you use outside the classroom?

1. Word Editor ☑
2. Presentation ☑
3. Spreadsheet ☑
4. Internet Explorer (and Firefox) ☑
5. Email (web-based interface - hw mail) ☑
6. Calculator ☑
7. Other (Specify) graphics editor, multi-media app. etc. ☑

Q11 - What are the purposes of using your portables outside the classroom?
(Please tick the appropriate box)

	Laptop	PDA	Mobile phone	Other
Taking notes	✓	✓		
Viewing instructor lecture notes	✓			
Access Internet sites	✓			
Chatting with colleges	✓			
Asking questions (via email)	✓			
Reading course materials	✓			
Playing games				
Reading email	✓			
Writing emails	✓			
Reading e-books	✓			
Using spreadsheets	✓			
Editing word documents	✓			
Others (Specify) checking calendar (PIM) time table entertainment		✓		

Q12 - Would you like to use your portables more outside the classroom?

1. Yes ☑
2. No ☐

If 'Yes'

Q12.1 - What stops you from using your portables more outside the classroom?

- lack of power socket
- lack of internet connectivity that is free.
- battery life

Q13 - What encourages you to use your portables outside the classroom?

- internet & quick backup information (PDA)

Portables' benefits and limitations

Q14 - How useful do you believe portables are: ***(Please tick the appropriate box)***

	Not useful	Somewhat useful	Very useful
Inside the classroom		✓	
Outside the classroom			✓

Q15 - Why do you believe portables ~~will~~/will not be useful for in-class learning activities?

- Unpractical when interaction (laptop / PDA)

(+ the previous listed disadvantages)

Q16 - Why do you believe the portables will/~~will not~~ be useful for out of class learning activities?

- Can bring it if you need with you.

(+ the previous advantages)

Portables and students' collaboration

Q17 - How often do you use your portables for collaborating with others (students and/or others)? ***(Please tick the appropriate box)***

	Inside the classroom	Outside the classroom
Daily		
Weekly		
Monthly		
Never	✓	

Rarely (a few times a year) ✓

Q18 - How often do you collaborate with other students face-to-face? ***(Please tick the appropriate box)***

	Inside the classroom	Outside the classroom
Daily		
Weekly (a few times/week)	✓	
Monthly		
Never		

Rarely (only during ~~vacations~~) ✓
(a few times a year)

Q19 - How often do you collaborate with other students using online techniques such as instant messaging (e.g. MSN Messenger), bulletin boards or emails? ***(Please tick the appropriate box)***

	Inside the classroom	Outside the classroom
Daily		
Weekly		✓ (if I have a question)
Monthly		
Never	✓	

Q20 - What is the purpose of your collaboration with other students? ***(Please tick all the appropriate boxes)***

	Inside the classroom	Outside the classroom
Discussing topics illustrated in the classroom		
Asking questions about the discussed topic in the class	(N.A)	✓
Discussing things not related to the discussed topic		✓
Chatting with friends and family		✓
Other		

Q21 - How has the use of portable devices helped you to collaborate with others?

- Saved Time
- Made interaction more frequent

Q22 - How has the use of portable devices hindered you from collaborate with others?

(None)

<u>Instructors' technology use impact on students' utilisation</u>

Q23 - Has the instructor's use of technology ever given you ideas for things to do or try? (Please explain)

(Not Sure) → Only used laptop in lectures for demonstrations of course material

Q24 - How do the tasks set by your instructors' encourage or require you to use portable technologies?

(Not really such tasks set yet)

Q25 - Has the instructor ever done anything that prevented or dismounted you from using portable technologies? (Please explain)

Not such things so far.

General perceptions of portables

Q26 - How do you travel to the university?

Public transport (Bus + train)

Q27 - How long is your journey to the university?

40 minutes

Q28 - Do you use your portables while travelling? *(Please tick all the appropriate boxes)*

Laptop	✓ (rarely)
PDA	✓
Mobile phone	
Other	

Q29 - What for?

Laptop

Revision (in desperate circumstances!)

PDA

- Reading news / e-books
- PIM

Mobile phone:
(N.A).

Other
(N.A.)

Q30 - How often do you bring each of the following to class with you: ***(Please tick all the appropriate boxes)***

	Daily	Weekly	Monthly	Never
Laptop	√(a3 (sometimes)			
PDA	√			
Mobile phone				
Other				

Q31 - Overall, how useful are your portables? ***(Please tick the appropriate box)***

	Laptop	PDA	Mobile phone	Other
Not useful				
Somewhat useful	√			
Very useful		√		

Q32 - We would like to understand the extent to which your use of portables is part of your day-to-day study. In order to help us understand this, we would like you to think about this hypothetical situation:
If your portables were taken away and you were not allowed to replace them, what effect would this have on you and your work:

Laptop:
- Will have to use remote access to my PC at home to access all course notes (which are too big to store on Uni's storage.
- Use USB thumbdrive & / internet connection to handle the storage.

PDA:
- All PIM function will have to go back to paper-based
- major impact on general attendance on [redacted] general organization of my life!

Mobile phone:
(N/A)

Other:
(N/A)

Q33 - What other comments do you have about your experience of using portables?

- Need longer battery life (laptop)
- Better connectivity needed (from supporting infrastructure)
- Could do with wider infrastructure support such as having a spare [redacted] and power socket in classroom / lecture theatre/ to use laptop with
- Faster [redacted], better coverage of wireless in some places, such as in ATLabs

Thank you very much for your time and cooperation